

4. Tides and Water Levels Requirements

4.1. General Project Requirements and Scope

4.1.1. Scope

The requirements and specifications contained in this section cover the water level and vertical datum requirements for operational support of hydrographic surveys conducted as part of the NOAA Nautical Charting Program. The scope of this support is comprised of the following functional areas:

1. Tide and water level requirements planning
2. Preliminary tidal zoning development
3. Control water level station operation, monitoring, and maintenance
4. Subordinate water level station installation, operation, monitoring, maintenance, and removal
5. Data quality control, processing, and tabulation
6. Tidal datum computation and tidal datum recovery
7. Generation of water level reducers and final tidal zoning
8. Quality control check of contractor submitted data to CO-OPS

For NOAA in-house surveys hydrographic survey, personnel from the NOAA's National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) are responsible for functional areas 1, 2, 3, 5, 6 and 7. NOS hydrographers shall be responsible for functional area 4 above.

For NOAA contract hydrographic surveys, NOS CO-OPS personnel are responsible for functional areas 1, 2, 3 and 8. NOAA contract hydrographers shall be responsible for functional areas 4 through 7 above. NOS CO-OPS will be responsible for operating, maintaining, and processing data from the National Water Level Observation Network (NWLON) control stations.

4.1.2. Objectives

The work performed according to the requirements and specifications of this document is required for NOS major program areas of navigational products and services. The first objective is to provide time series of water level reducers that can be applied to hydrographic soundings so that they can be corrected to chart datum. A second objective is to establish and/or recover tidal datums relative to local benchmarks at each station that can be used for continuing and future hydrographic surveys in the area. A third objective is to provide new information or updated information that can be used to update NOAA tide prediction products and tidal zoning for promote safe navigation applications.

4.1.3. Planning and Preliminary Tidal Zoning

CO-OPS is responsible for all planning of tide requirements for NOS hydrographic surveys. CO-OPS will analyze historical data and tidal characteristics for each project area, specify operational NOS control stations, specify subordinate tide station locations to be installed, and provide the preliminary tidal zoning to be used during survey operations. CO-OPS will provide 6-minute interval tide predictions relative to chart datum for appropriate NOS control stations prior to each survey and will also provide historical published bench mark information available for all historical tide stations specified for reoccupation. If CO-OPS provides a new preliminary tidal zoning scheme, the contractor must use that zoning scheme first for each project, and then, may generate a new scheme if the one provided is not adequate. At the conclusion of the survey, the contractor shall suspend the use of preliminary zoning scheme and develop

final zoning scheme using correctors derived from the subordinate stations installed during the survey. Refer to Section 4.5.2 for further details.

4.1.4. NOS Control Stations and Data Quality Monitoring

National Water Level Observation Network

CO-OPS manages the NWLON of approximately 196 (as of March 2007) continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with satellite radios, near real-time (within about 30 minutes of collection) raw data are made available to all users through the CO-OPS Web homepage at www.tidesandcurrents.noaa.gov.

Verified products, such as edited 6-minute data, hourly heights, high and low waters, and monthly means are made available over the Web within one to four weeks after data collection. NWLON data and accepted tidal datums are used in hydrographic surveys either to provide tide reducers directly or for control for datum determination at subordinate (short-term) stations. Preliminary and verified data are made available over the Web relative to MLLW datum, station datum, or special water level datum (such as Columbia River datum) as an user option in the interface.

Data Quality Monitoring

CO-OPS has an in-place Continuous Operational Real-Time Monitoring System (CORMS) that provides quality control and system monitoring functions on a 24 hour/day, 7 days/week, all year around basis for CO-OPS monitored gauges. CORMS will monitor the status and performance of all in-house hydro gauges equipped with satellite radios using the NOS satellite message format and that are installed by either CO-OPS, NOAA Ships, Navigational Response Teams (NRT), or CO-OPS IDIQ contractors for NOAA in-house hydro projects only, and once these gauges are listed on the hydro hot list by CO-OPS, as it does for all other NOS water level systems, including all NWLON stations. The CORMS system description can be found in System Development Plan, CORMS. CORMS is a NOS provided support function to the operational field parties and does not relieve the hydrographer of responsibility for performing QC and ensuring proper gauge operation. As stated in Section 4.1.1 Scope above, for NOAA hydrographic contract surveys, the contractor is responsible for all data monitoring, repairs, and proper functioning of the subordinate gauges.

4.1.5. General Data and Reference Datum Requirements

The present NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) based on the NOAA National Tidal Datum Epoch (NTDE) of 1983-2001 as defined in the *Tide and Current Glossary*. All tidal datum computations and water level reductions shall be referenced to this datum. In non-tidal areas, including the Great Lakes, special low water datums have been defined for specific areas and are used as chart datum in these locations. In some cases where historical sites are re-occupied, site datum shall be zeroed to a pre-established MLLW datum held on a bench mark. In that case, data can be acquired relative to MLLW for immediate application during the survey. At present, in Great Lakes areas, a special Low Water Datum relative to IGLD 85 is the reference datum.

4.1.6. Error Budget Considerations

The water level reducers can be a significant corrector to soundings to reduce them relative to chart datum especially in shallow water areas with relatively high ranges of tide. The errors associated with water level reducers are generally not depth dependent, however. The portion of the error of the water level reducers must be balanced against all other sounding errors to ensure that the total sounding error budget is not exceeded. The allowable contribution of the error for tides and water levels to the total survey error budget falls between 0.20 m and 0.45 m (at the 95% confidence level) depending on the complexity of the tides.

The total error of the tides and water levels can be considered to have component errors of:

1. The measurement error of the gauge/sensor and processing error to refer the measurements to station datum. Gauges/sensors need to be calibrated, and sensor design and data sampling need to include strategies to reduce measurement errors due to waves, currents, temperature, and density effects. The measurements need to be properly referenced to the bench marks and tide staffs, as appropriate and monitored for vertical stability. The measurement error, including the dynamic effects, should not exceed 0.10 m at the 95% confidence level. The processing error also includes interpolation error of the water level at the exact time of the soundings. An estimate for a typical processing error is 0.10 m at the 95% confidence level.
2. The error in computation of tidal datums for the adjustment to an equivalent 19-year National Tidal Datum Epoch (NTDE) periods for short term stations. The shorter the time series, the less accurate the datum, i.e. bigger the error. An inappropriate control station also decreases accuracy. The NTDE does not apply in the Great Lakes, however the accuracy of datum based on shorter time series is analogous. The estimated error of an adjusted tidal datum based on one month of data is 0.08 m for the east and west coasts and 0.11 m for the Gulf coast (at the 95% confidence level).
3. The error in application of tidal zoning. Tidal zoning is the extrapolation and/or interpolation of tidal characteristics from a known shore point(s) to a desired survey area using time differences and range ratios. The greater the extrapolation/interpolation, the greater the uncertainty and error. Estimates for typical errors associated with tidal zoning are 0.20 m at the 95% confidence level. However, errors for this component can easily exceed 0.20 m if tidal characteristics are very complex, or not well-defined, and if there are pronounced differential effects of meteorology on the water levels across the survey area.

Project planning by NOS attempts to minimize and balance these potential sources of errors through the use and specification of accurate reliable water level gauges, and optimization of the mix of zoning required, the number of station locations required, and the length of observations required within practical limits of the survey area and survey duration. The practical limits depend upon the tidal characteristics of the area and suitability of the coastline for the installation and operation of appropriate water level stations.

4.2. Data Collection and Field Work

The hydrographer shall collect continuous and valid data series. Accurate datums cannot be computed for a month of data with a break in the water level measurement series in excess of three days. Even breaks of significantly less than three days duration will not allow for interpolation during times when strong meteorological conditions are present and in areas with little periodic tidal influence. Any break in the water level measurement series affects the accuracy of datum computations. Breaks in data also result in

increased error in the tide reducers when interpolation is required to provide data at the time of soundings. At a critical measurement site where the water level measurement data cannot be transmitted or monitored during hydrographic operations, an independent backup sensor or a complete redundant water level collection system shall be installed and operated during the project.

4.2.1. Water Level Station Requirements

Data from NOS National Water Level Observation Network (NWLON) stations will be provided to support hydrographic survey operations where appropriate. Data provided are relative to Chart Datum which is Mean Lower Low Water for the 19-year National Tidal Datum Epoch (NTDE).

The acquisition of water level data from subordinate locations may be required for hydrographic surveys and if so shall be specified by NOS in each individual set of Project Instructions or Statement of Work. These stations shall be used to provide 6-minute time series data, tidal datum references and tidal zoning which all factor into the production of final tide reducers for specific survey areas. Station locations and requirements may be modified after station reconnaissance or as survey operations progress. Any changes shall be made only after consultation between the CO-OPS and the hydrographer (and COTR if contract survey) as moving required stations to new locations may require new seven-digit station identifier numbers and new/historical station and bench mark information.

The duration of continuous data acquisition shall be a 30-day minimum except for zoning stations. Data acquisition shall be from at least 4 hours before the beginning of the hydrographic survey operations to 4 hours after the ending of hydrographic survey operations, and/or shoreline verification in the applicable areas. Stations identified as “30-day” stations are the “main” subordinate stations for datum establishment, providing tide reducers for a given project and for harmonic analysis from which harmonic constants for tide prediction can be derived. At these stations, data must be collected throughout the entire survey period in specified areas for which they are required, and not less than 30 continuous days are required for accurate datum determination. Additionally, supplemental and/or back-up gauges may also be necessary based upon the complexity of the hydrodynamics and/or the severity of environmental conditions of the project area.

In non-tidal areas the correctors for hydrographic soundings are simply water level measurements relative to a specified local low water level datum established for navigational purposes. Laguna Madre and parts of Pamlico Sound are examples of such areas classified as non-tidal which have special low water datums. Some river areas also have special datums due to the effects of seasonal changes on the river, e.g., Columbia River Datum, Hudson River datum, and Mississippi River Low Water are examples of this case. Great Lakes NWLON permanent stations will provide water level data referenced to an established Low Water Datum relative to International Great Lakes Datum of 1985 (IGLD 85) (see Standing Project Instructions: Great Lakes Water Levels, June 1978).

4.2.2. Water Level Measurement Systems and Data Transmissions

Water Level Sensor and Data Collection Platform

The water level sensor shall be a self-calibrating air acoustic, pressure (vented), or other suitable type that is approved by CO-OPS. The sensor measurement range shall be greater than the expected range of water level. Gauge/sensor systems shall be calibrated prior to deployment, and the calibration shall be checked after removal from operations. The calibration standard’s accuracy must be traceable to National Institute of Standards and technology (NIST). The required water level sensor resolution is a function of the tidal range of the area in which hydrographic surveys are planned. For tidal range less than or equal to 5 m, the required water level sensor resolution shall be 1 mm or better; for tidal range between 5 m and 10 m, the

required water level sensor resolution shall be 3 mm or better; and for tidal range greater than 10 m, the required water level sensor resolution shall be 5 mm or better.

The Data Collection Platform (DCP) shall acquire and store water level measurements at every 6-minutes. The water level measurements shall consist of an average of at least three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples which comprise the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data is required for compatibility with the NWLON stations, and the standard deviation provides valuable data quality information regarding each measurement. The clock accuracy of a satellite radio system shall be within 5 seconds per month so that channel “stepping” does not occur. Non-satellite radio systems shall have a clock accuracy of within one minute per month. Known error sources for each sensor shall be handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types.

The NOS is currently using the Aquatrak® self-calibrating air acoustic sensors at the majority of the NWLON stations. (For further information refer to *Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual*, NOAA/NOS, January 1991 and *User's Guide for 8200 Acoustic Gauges*, NOAA/NOS, Updated August 1998). At stations where the acoustic sensor can not be used due to freezing or the lack of a suitable structure, either a ParoScientific intelligent pressure (vented) sensor incorporated into a gas purge system, or a well/float with absolute shaft angle encoder (Great Lakes Stations) are used for water level measurements. (For further information refer to *User's Guide for 8200 Bubbler Gauges*, NOAA/NOS, Updated February 1998).

In each and any case, the water leveling sampling/averaging scheme shall be as described above. For short term subordinate stations which are installed to support NOS hydrographic surveys, the use of air acoustic sensor is preferred over pressure sensor whenever possible. Where the air acoustic sensor can not be installed, NOS uses a vented strain gauge pressure sensor in a bubbler configuration (Refer to *User's Guide for 8200 Bubbler Gauges*, NOAA/NOS, updated February 1998). When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start, (2) at frequent intervals during deployment, and (3) at the end of a deployment. Frequent gauge/staff comparisons (at least two times per week or minimum eight times per month) during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations shall be at least three hours long at the beginning and end of deployment and the periodic observations during deployment shall be 1 hour long. Along with the averaging procedure described above which works as a digital filter, NOS uses a combination protective well/parallel plate assembly on the acoustic sensor and a parallel plate assembly (with 2" orifice chamber) on the bubbler orifice sensor to minimize systematic measurement errors due to wave effects and current effects, as shown in Figure 4.1.

When pressure sensors are used to collect the water level data, orifice should be mounted on vertical surface such as piling of a wharf so that precise elevation of orifice below a staff stop could be measured with a steel tape, and the elevation of the staff stop can be measured via differential leveling to the nearest benchmark and with the primary bench mark. If the orifice is mounted vertically and its elevation can be determined precisely with reference to the primary bench mark, then staff to gauge readings are not necessary, and the requirement for staff-to-gauge readings is waived. If the orifice can not be mounted to a vertical surface i.e. if the elevation of the orifice can not be determined precisely with the primary bench mark, then staff-to-gauge readings are required to relate the water level datums to the bench marks.

Data Transmissions

The Data Transmissions requirements are applicable where CO-OPS is monitoring the gauges as described in Section 4.1.4 above. The ability to monitor water level measurement system performance for near real-time quality assurance is essential to properly support hydrographic survey operations. Therefore, it is required that, where access to the satellite is available, the measurement system shall be equipped with a GOES transmitter to telemeter the data to NOS every three hours or hourly. The data transmissions must use a message format identical to the format as currently implemented in NOS' Next Generation Water Level Measurement Systems (NGWLMS). This is required to assure direct compatibility with the NOS Data Management System (DMS). This data format is detailed in the reference document "NGWLMS GOES MESSAGE FORMATTING" (refer to Section 4.7 for References). Once station and gauge information is configured in DMS and station listed on the Hydro Hot List (HHL), the NOS Continuous Operational Real-Time System (CORMS) will monitor all water level measurement system GOES transmissions to assure they are operating properly, provided that the GOES data transmitted is compatible with NOS format. Data that is not transmitted by GOES, or data transmitted but not in NOS compatible GOES format, or is submitted to CO-OPS on electronic formats currently used such as, CD-ROM, DVD-ROM or such other digital media, must also conform to the format specified in the above document so that data can be loaded properly into DMS software. Refer to Section 4.6.3 for further details about the water level data format specifications.

Close coordination is required between hydrographer and Requirements and Development Division (RDD) of CO-OPS for all hydrographic water level installations with satellite transmission capability. NOS will assist in acquiring assigned platform ID's, time slots, etc. At least three business days prior to the initiation of GOES data transmission in the field, information about the station number, station name, latitude, longitude, platform-ID, transmit time, channel, and serial numbers of sensors, and DCP shall be faxed, phoned, or sent to RDD. Test transmissions conducted on site are outside this requirement. This station and DCP information must be configured in DMS before data transmissions begin so that the data will be accepted in DMS. The documentation required prior to transmission in field is defined in the NGWLMS Site Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 4.6 Data Submission Requirements).

4.2.3. Station Installation, Operation and Removal

Hydrographers shall obtain all required permits and permissions for installation of the water level sensor(s), Data Collection Platforms (DCP), bench marks, and utilities, as required. The hydrographer shall be responsible for security and/or protective measures, as required. The hydrographer shall install all components in the manner prescribed by manufacturer, or installation manuals. The hydrographer or contractor shall provide CO-OPS of the position of all tide gauges installed before hydrography begins, including those that were not specified in the Statement of Work or Project Instructions, as appropriate. The positions of bench marks and stations installed or recovered shall be obtained as latitudes and longitudes (degrees, minutes, and hundredths of seconds).

The following paragraphs provide general information regarding requirements for station installation, operations and maintenance, and station removal.

Station Installation

A complete water level measurement gauge installation shall consist of the following:

- A. The installation of the water level measurement system (water level sensor(s), DCP, and satellite transmitter) and its supporting structure and a tide staff if required.
- B. The recovery and/or installation of a minimum number of bench marks and a level connection between the bench marks and the water level sensor(s), and tide staff as appropriate.
- C. The preparation of all documentation and forms.

Operation and Maintenance

When GOES telemetry and NOS satellite message format is used, the hydrographer shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. This monitoring can be performed by accessing the COOPS web page (<http://www.TidesandCurrents.noaa.gov>). The data over this system are typically available for review within three to four hours after collection.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate maintenance forms (see section on water level station documentation below) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time of start and completion of the maintenance activity; date and time of adjustments in sensor/DCP, datum offset, or time; personnel conducting the work; parts or components replaced; component serial numbers; tests performed; etc.

Removal

A complete removal of the water level measurement gauge shall consist of the following:

- A. Closing levels - a level connection between the minimum number bench marks and the water level sensor(s) and tide staff as appropriate.
- B. Removal of the water level measurement system and restoration of the premises, reasonable wear and tear accepted.
- C. The preparation of all documentation, forms, data, and reports.

4.2.4. Tide Staffs

Staff

The hydrographer shall install a tide staff at a station if the reference measurement point of a sensor (zero of a gauge) cannot be directly leveled to the local bench marks, e.g. orifice is laid over sea floor in case of pressure based bubbler gauges. Even if a pressure gauge can be leveled directly, staff readings are still required for assessment of variations in gauge performance due to density variations in the water column over time. The tide staff shall be mounted independent of the water level sensor so that stability of the staff or sensor is maintained. Staff shall not be mounted to the same pile on which the water level sensor is located. The staff shall be plumb. When two or more staff scales are joined to form a long staff, the

hydrographer shall take extra care to ensure the accuracy of the staff throughout its length. The distance between staff zero and the rod stop shall be measured before the staff is installed and after it is removed and the rod stop above staff zero height shall be reported on the documentation forms.

In areas of large tidal range and long sloping beaches (i.e. Cook Inlet and the Gulf of Maine), the installation and maintenance of tide staffs can be extremely difficult and costly. In these cases, the physical installation of a tide staff(s) may be substituted by systematic leveling to the water's edge from the closest bench mark. The bench mark becomes the "staff stop" and the elevation difference to the water's edge becomes the "staff reading".

Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start of water level data collection, (2) at frequent intervals during deployment, and (3) at the end of a deployment before gauge has been removed. Frequent gauge/staff comparisons during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The staff to gauge observations at the start and end of deployment shall be at least each three hours long and the periodic observations during the deployment shall be at least 1 hour long. The staff to gauge observations shall be performed three times per week, during each week of the project, with at least an hour long observations of 6 minute interval for each time. Where staff to gauge observations can not be performed three times a week as required then an explanation is required for the deficiency of number of observations and staff to gauge observations shall be performed at least (a) minimum eight times spread out over each month (e.g. two times per week) and at each time at least 1 hour of observations at 6 minute interval, or (b) minimum of four times spread out over each month (e.g. one time per week) and at each time at least 2 hours of observations at 6 minute interval, whichever is convenient.

The staff-to-gauge differences should remain constant throughout the set of observations and show no increasing or decreasing trends. After the water level data has been collected, the averaged staff-to-gauge shall be applied to water level measurements to relate the data to staff zero. A higher number of independent staff readings decrease the uncertainty in transferring the measurements to station datum and the bench marks. Refer to Figure 4.2 for an example pressure tide gauge record.

If the old staff is found destroyed by elements during the deployment, then a new staff shall be installed for the remainder period of the deployment and a new staff to gauge constant needs to be derived by new sets of staff to gauge observations. Also when a staff or an orifice is replaced or re-established, check levels shall be run to minimum of three bench marks including the PBM. Refer to Section 4.2.5 for leveling frequency and other leveling requirements.

Bubbler Orifice and Parallel Plate Assembly

This bottom assembly is made of red brass, its chemical properties prevent the growth of marine life by the slowly releasing copper oxide on its metal surface. A Swagelok® hose fitting is screwed into the top end cap and is used to discharge the Nitrogen gas. The Nitrogen gas flows through the bottom of the orifice at a rate sufficient to overcome the rate of tidal change and wave height. This opening establishes the reference point for tidal measurements. The parallel plates produce a laminar flow across the orifice to prevent venturi effect. A two inch by eight inch pipe provides the correct volume gas for widest range of surf conditions encountered by most coastal surveys.

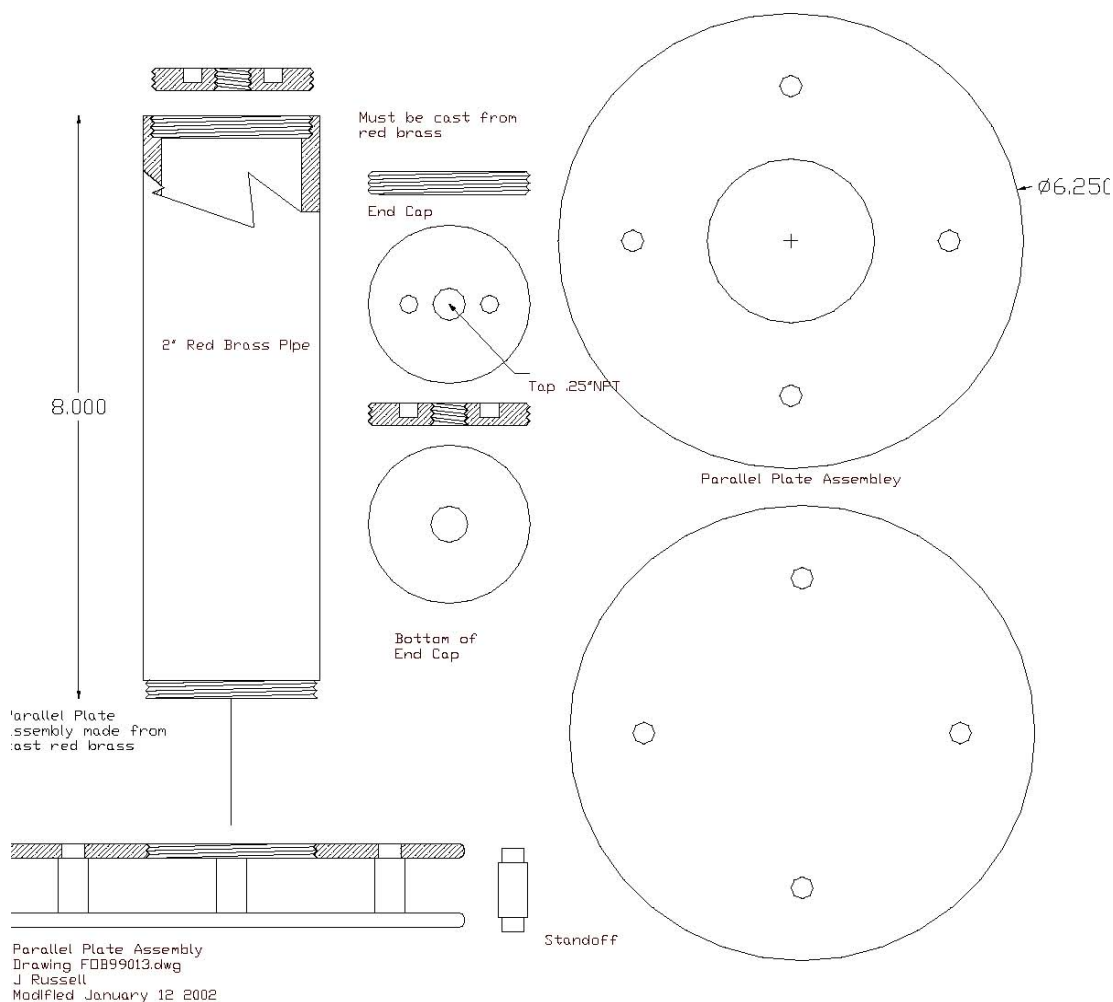


Figure 4.1. Bubbler Orifice Bottom Assembly

Station Name:_____ **Station No. (7 digit #)** _____

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4.2.5. Bench Marks and Leveling

Bench Marks

A bench mark is a fixed physical object or marker (monumentation) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks in the vicinity of a water level measurement station are used as the reference for the local tidal datums derived from the water level data. The relationship between the bench marks and the water level sensor or tide staff shall be established by differential leveling.

Number and Type of Bench Marks

The number and type of bench marks required depends on the duration of the water level measurements. The *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, dated October 1987*, specifies the installation and documentation requirements for the bench marks. Each station will have one bench mark designated as the primary bench mark (PBM), which shall be leveled to on every run. The PBM is typically the most stable mark in close proximity to the water level measurement station. The contractor shall select a PBM at sites where the PBM has not already been designated. For historic NOS station reoccupations, CO-OPS will furnish the name of the PBM and PBM elevation above station datum, as appropriate and if available.

The most desirable bench mark for GPS observations will have 360 degrees of horizontal clearance around the mark at 10 degrees and greater above the horizon and stability code of A or B. Refer to Section 4.2.8 GPS Observations, and *User's Guide for GPS Observations, Updated January 2003*, for further information.

If the PBM is determined to be unstable, another mark shall be designated as PBM. The date of change and the elevation difference between the old and new PBM shall be documented. NOAA will furnish the individual NOS standard bench mark disks to be installed. Bench mark descriptions shall be written according to *User's Guide for Writing Bench Mark Descriptions, updated January 2003*.

Leveling

At least third-order levels shall be run at short-term subordinate stations operated for less than one-year. Requirements for higher order levels will be specified in individual project instructions, as appropriate. Standards and specifications for leveling are found in *Standards and Specifications for Geodetic Control Networks and Geodetic Leveling (NOAA Manual NOS NGS 3)*. Additional field requirements and procedures used by NOS for leveling at tide stations can be found in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations*. Electronic digital/barcode level systems are acceptable. Specifications and standards for digital levels can be found in *Standards and Specifications for Geodetic Control Networks* and additional field requirements and procedures used by NOS for electronic leveling at water level stations can be found in the *User's Guide for Electronic Levels, updated January 2003*.

Leveling Frequency

Levels shall be run between the water level sensor(s) or tide staff and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. In any case, levels are required at a maximum interval of six (6) months during the station's operation, and are recommended after severe storms, hurricanes, earthquakes to document stability (see stability discussed below).

Bracketing levels to appropriate number of marks (five for 30-day minimum stations) are required (a) if smooth tides are required 30 days or more prior to the planned removal of a applicable gauge(s), or (b) after 6 months for stations collecting data for long term hydrographic projects.

Stability

If there is an unresolved movement of the water level sensor or tide staff zero relative to the PBM, from one leveling to the next, of greater than 0.006 m, the hydrographer shall verify the apparent movement by re-running the levels between the sensor zero or tide staff to the PBM. This threshold of 0.006 m should not be confused with the closure tolerances used for the order and class of leveling.

4.2.6. Water Level Station Documentation

The field team shall maintain a documentation package for each water level measurement station installed for hydrographic projects. The documentation package shall be forwarded to CO-OPS within 10 business days of a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, or d) removal of the station.

Generally, all documentation submitted (see Section 4.6 for Data Submission Requirements) shall be forwarded to CO-OPS when a station is installed. For other situations, only information that has changed shall be submitted (e.g., levels and abstract for bracketing or removal levels, NGWLMS Site Report for maintenance and repair or station removal, etc.)

4.2.7. Additional Field Requirements

- A. Generally upon completion of the data acquisition for each gauge installed, the data must be sent all together for 30-day minimum stations unless the data are transmitted via satellite. For long term stations running more than three months, the data shall be sent periodically (monthly) unless the data are transmitted via satellite.
- B. All water level data from a gauge shall be downloaded and backed up at least weekly on electronic formats currently used such as CD-ROM or DVD-ROM, whether the gauge data are sent via satellite or not.
- C. For new stations that do not have station numbers assigned, once the location of the gauge has been finalized then contact CO-OPS and provide latitude and longitude of the gauge site at least three business days prior to actual installation of the gauge in field. CO-OPS will assign a new station number within three business days and inform the hydrographer.
- D. The progress sketch shall show the field sheet, layout, area of hydrography, gauge locations, and other information as appropriate. Verify the location of the gauge as shown on the progress sketch, bench mark and tide station location sketch, field tide note, NGWLMS Site Report (or Tide Station Report or Great Lakes Water Level Station Report, as appropriate).

4.2.8. Geodetic Connections and Datums Relationship

Tidal datums are local vertical datums which may change considerably within a geographical area. A geodetic datum is a fixed plane of reference for vertical control of land elevations. The North American Vertical Datum of 1988 (NAVD 88) is the accepted geodetic reference datum of the National Geodetic Spatial Reference System and is officially supported by the National Geodetic Survey (NGS) through a network of GPS continuously operating reference stations. The relationship of tidal datums to NAVD 88 has many hydrographic, coastal mapping and engineering applications including monitoring sea level change and the deployment of GPS electronic chart display and information systems, etc.

Existing geodetic marks in the vicinity of a subordinate tidal station shall be searched for and recovered. A search routine is available at <http://www.ngs.noaa.gov>. An orthometric level connection and ellipsoidal GPS tie is required at a subordinate tide station which has geodetic bench marks located nearby as stated below for NAVD 88 Level Tie and NAD 83 GPS Tie requirements. NAVD 88 heights for published bench marks are given in Helmert orthometric height units by NGS. The GPS ellipsoid network height accuracies are classified as conforming to 2 cm or 5 cm standards accuracies (Refer to *NOAA Technical Memorandum NOS NGS-58*). At the present time, GPS ellipsoid heights conforming to the 2 cm accuracy standards are required for contract hydrographic surveying projects. Refer to Section 4.2.10 GPS Observations and *User's Guide for GPS Observations, NOAA/NOS, Updated March 2007*.

A connection to the geodetic datums at a water level station enhances the value of the tidal data, allowing comparison with other data sets. The geodetic network essentially serves as a global reference datum to which all tidal datums can be referenced. The connection to geodetic datums involves the following three ties:

1. NAVD 88 Level Tie
2. NAD 83 GPS Tie
3. NAVD 88 GPS Tie

4.2.9. NAVD 88 Level Tie

At all water level stations, a valid level tie to at least two Geodetic Bench Marks (GBM) is required on each set of levels, where appropriate marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet.

At stations supporting hydro or other special projects, the tie shall be consistent with the accuracy of the levels required for the project. Information on performing a valid level tie is provided in the FGCC Standards and Specifications for Geodetic Control Networks, listed at the following website:

http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5.

Also, Section 3.4 of Reference 2 *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* provides information regarding how to perform a valid level tie.

The Second Order, Class I tie is a requirement for digital levels to be accepted into the NGS database. Since a level connection to GBMs with dynamic heights defines the IGLD 85 datum offset at each station in the Great Lakes, a valid connection to at least two GBMs is required at each site in the Great Lakes.

A note shall be made in the remarks of the leveling section of the Tide Station Site Report that a valid tie was achieved or not achieved. If a valid tie is not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If the water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the level tie requirement is waived.

4.2.10. GPS Observations

GPS observations are required to obtain elevation ties between the tidal datums and GPS derived datums.

(A) References and standards:

Static GPS observations shall be performed at water level stations in accordance with Reference 8 "*User's Guide for GPS Observations*", NOAA/NOS Updated March 2007. Reference 20 "*NOS NGS 58*" provides further details. These guidelines are written for establishing GPS derived ellipsoid height accuracy standards of 2 cm as outlined in NGS-58 document, for all survey projects, and special project applications.

Static GPS surveys shall be conducted on a minimum of one bench mark at each subordinate water level station installed/occupied for hydrographic or photogrammetric surveys.

Static GPS surveys shall be conducted at water level stations concurrently with the occupation of NAVD 88 marks, if possible, to accomplish water level datum transfers using GPS-derived orthometric heights.

(B) Equipment and accuracies:

High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites.

A choke ring antenna is preferred, however, any geodetic quality ground plane antenna may be used. More important than antenna type, i.e. choke ring or ground plane, is that the same antennas or identical antennas should be used during the entire observing sessions. (If not, a correction for the difference in antenna phase patterns (modeled phase patterns) must be applied.) This is extremely critical for obtaining precise vertical results. The antenna cable length between the antenna and receiver should be kept to a minimum when possible; 10 meters is the typical antenna cable length. If a longer antenna cable is required, the cable must be fabricated from low loss coaxial cable (RG233 for up to 30 meters and RG214 over 30 meters).

A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, 2 meter pole with three adjustable legs, a bulls eye bubble to plumb the antenna, and a magnetic compass to align the antenna to North. These fixed height tripods reduce the chance of introducing an Height of Instrument (HI) "blunder" during the post-processing of the data.

The manufacturer, model, and complete serial numbers of all receivers and antennas must be noted for each occupation on each station/bench mark observation log sheet as shown in Figure 4.18.

(C) Criteria for bench mark selection for GPS observations

The GPS Water Level Station Bench Mark (GPSBM) shall be selected based on the following criteria: (1) permanence or stability; (2) historic GPS use; (3) satellite visibility; and (4) safety and convenience.

(1) Permanence or stability of bench marks

NGS has defined the following monumentation quality codes, also called the stability codes, for various bench mark settings.

Stability code A – monuments of the most reliable nature which may be expected to hold their elevations very well; e.g. Class A rod marks, or marks installed on large boulders/rock outcrop.

Stability code B – monuments which probably hold their elevations well; e.g. Class B rod marks, or marks installed on large concrete footings/foundations.

Stability code C – monuments which may hold their elevations but which are commonly subject to surface ground movements; e.g. pavement or concrete monuments.

Stability code D – movements of questionable or unknown reliability.

The station bench mark selected for GPS observations shall be of stability code A or B. GPS observations on the primary bench mark (PBM) are preferred if the PBM is either stability code A or B, and is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations, unless NGS has previously made GPS observations on those marks. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark.

(2) Historic GPS use

In many states, CO-OPS has provided NGS with lists of selected marks suitable for GPS observations at water level stations, and NGS has completed observations on these marks. Some tidal marks designated as Federal Base Network (FBN) or Cooperative Base Network (CBN) marks may be of stability code C. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. If leveling reveals instability of the mark over time, select another mark.

Priority shall be given to a GBM for GPS observations because the GBM already has a NSRS height (NAVD 88). The GBM considered here is one of the 10 tidal or water level bench marks at a water level station.

(3) Satellite visibility

The most desirable bench mark for GPS observations should have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have these clearances, if at all possible. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new mark (stability A or B) shall be established. This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. If electronic leveling equipment is used, then a note shall be made, either in the APP field of the electronic leveling HA file or on a copy of the published bench mark sheet, stating the suitability of GPS observations for each mark. The GPS visibility obstruction diagram shall also be completed for each mark observed.

GPS visibility obstruction diagram shall also be completed for each mark observed as shown in Figure 4.20.

(4) Safety and convenience

The location of the GPS bench mark should be safe, secure, and convenient. Bench mark locations which allow unattended GPS data collection are desirable as the field crew can multi-task at the same time as collecting the GPS data. The safety of the GPS equipment (vandalism proof) should be considered in the mark selection process.

The bench mark selected for GPS observations should be located on public property rather than on private property, as permissions from private owners may be required in the future to access the bench mark and for collecting the GPS data. The distance from the station DCP should also be convenient.

(D) Recording of data

Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites.

(E) Position and photograph of the GPS bench mark

GPS (horizontal) positions (latitude and longitude) of each bench mark installed or recovered shall be listed on the HA files for laser levels, if used, or on the bench mark descriptions sheet for optical leveling, as applicable, at each subordinate water level station occupied for hydrographic or photogrammetric surveys.

Digital photographs shall be taken of all station bench mark disks in accordance with Reference 23 - *Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005*". A minimum of three photos shall be taken: close-up of the disk face; chest or waist level view of the disk and setting; and horizontal view of location and direction of view. The digital file for a bench mark photo shall have the bench mark designation in its file name, followed by the view, with a jpg extension, i.e. CONTAINER setting.jpg, or CONTAINER location NE.jpg.

A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 4.22. If digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 4.21. A digital photo of the stamping is preferred over rubbing of the mark.

Photos shall also be taken of station components such as protective wells, staffs, tide house, DCPs, sensors, etc. One general location photo shall be taken showing the water level station in relationship to its supporting structure and the local body of water. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the pressure sensor photo for DCP1 at San Francisco shall be named as 94142901 sensor N1.jpg.

(F) Miscellaneous

Additional GPS suitable marks may be connected during the static survey using rapid static GPS procedures to verify bench mark stability, if time and personnel resources are available. Priority shall be given to connecting to the NSRS, particularly to the North American Vertical Datum of 1988 (NAVD 88) bench marks.

4.2.11. North American Datum 1983 (NAD 83) GPS Tie

The NGS Online Positioning User Service (OPUS) is now used extensively for quick and convenient processing of the GPS raw data for a variety of applications. The position solution provided by OPUS is considered preliminary data and is not retained by NGS. Further information regarding using OPUS is provided in the next section.

The expected ellipsoid height accuracy for a 4 hour OPUS solution is 1.8 cm (at the 67% confidence level), and that is desirable, practical, and achievable with the requirements as specified in reference 20, NOAA Technical Memorandum “*NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3*”.

The length of GPS observation sessions depends upon the length of time the field crew has available for GPS observations, security of the equipment, number of satellites available at a site, number of GPS receivers available for GPS observations, etc.

For water level stations, collect a minimum of 4 hours of GPS data on the GPSBM. Extra care shall be taken to ensure that the antenna height is precisely recorded, and that the antenna setup is stable. A continuous long session (at least 4 hours long but less than 24 hours) repeated annually is preferred to two or more shorter sessions (of less than 4 hours each) repeated on the same visit, providing better data for OPUS and more independent observations.

After the data collection session is complete, two independent downloads are required from the GPS receiver to the laptop computer. If one downloaded file gets corrupted, the other file may have good data. Do not make a copy of the downloaded file, as both the files will have the same problem, if there is a problem. Follow the NGS guidelines for naming these files. Submit both copies of the digital GPS data along with the necessary documentation as specified in the “*User’s Guide for GPS Observations, Updated March 2007*”.

4.2.12. GPS Data Processing Using OPUS

Field parties shall use OPUS for processing the raw GPS observations. OPUS provides an easily accessible, rapid method for submitting GPS data and receiving an almost instantaneous solution response from NGS via email.

The NGS OPUS web page can be obtained at <http://www.ngs.noaa.gov/OPUS/>. The following information is found on the OPUS web page but is also presented here for convenience of the reader.

OPUS allows users to submit their GPS data files to NGS, where the data will be processed to determine a position using NGS computers and software. Each data file that is submitted will be processed with respect to three CORS sites. The sites selected may not be the nearest to your site but are selected by distance, number of observations, site stability, etc. The position for your data will be reported back to you via email in both ITRF and NAD 83 coordinates as well as Universal Transverse Mercator (UTM), U. S. National Grid (USNG) and State Plane Coordinates (SPC) northing and easting.

OPUS is completely automatic and requires only a minimal amount of information from the user:

1. The email address where you want the results sent.
2. The data file that you want to process (which you may select using the browse feature; raw or RINEX accepted).
3. The antenna type used to collect this data file (selected from a list of calibrated GPS antennas).
4. The height of the Antenna Reference Point (ARP) above the monument or mark that you are positioning.

Once this information is complete, you then click the Upload button to send your data to NGS. Your results will be emailed to you, usually within a few minutes. You may upload multiple data files in a zip archive if you wish. However, be careful, the options that you choose will be applied to all of the data files in that archive (i.e. the same antenna type, ARP height will be used for all of the files in the zip file).

The following are some simple guidelines for analyzing the OPUS solutions.

1. Make sure the antenna type and the ARP height are correct.
2. Review the solution statistics:
 - a. A good quality OPUS run should typically use 90% or more of your observations.
 - b. OPUS should have fixed at least 80% of the ambiguities.
 - c. The overall RMS should seldom exceed 3 cm.
 - d. The maximum peak to peak errors should be less than 2 cm for horizontal and 4 cm for vertical (This depends, of course, on the accuracy you are trying to achieve).

NGS needs to receive orbit data from IGS in order to obtain a solution. If the data is submitted too quickly, the submitter may need to re-submit the data at a later time. For best results, submit the GPS data

to OPUS at least 17 hours after the first midnight (in Greenwich Mean Time) following the time when the observations were recorded. Compare the resultant solution to the last previous solution made at the station, if available, to ensure that you do not have a blunder in the antenna setup. This will be revealed by a noticeable discrepancy in the ellipsoid height. Include a copy of the solution in the station inspection documentation package submitted to CO-OPS RDD/OET, as well as the GPS data sets.

4.2.13. OPUS DB Preliminary Information

Pending NGS support, OPUS DB will be released by NGS. This advanced version of OPUS will submit OPUS solutions directly to the NGS database if all required documentation is provided by the submitter. Further guidance will be provided once OPUS DB is released and these specifications will be updated as appropriate. Any data sets submitted to OPUS and the results will be subsequently re-submitted by CO-OPS' RDD/OET to OPUS DB to ensure the data is published by NGS.

Height modernization guidelines are here: <http://www.ngs.noaa.gov/heightmod/guidelines.shtml>

The Opus DB datasheet concept is fully listed at the following NGS web site:
<http://www.ngs.noaa.gov/PROJECTS/draft/OPUS/OPUS-DB-concept.htm>

The following tables identify the required data elements and optional data elements for OPUS DB
Respectively:

REQUIRED DATA ELEMENTS (15 each):

ELEMENT	RATIONALE
e-mail	For identification & correspondence.
Filename	Necessary to compute position.
Antenna	Necessary to compute position.
antenna height	Necessary to compute position.
name of submitting agency	Identifies the observer.
permanent identifier (PID)	Identifies the station.
Designation	Identifies the station.
descriptive text	Aids in station recovery.
Rod/pipe depth & units	Describes monumentation quality.
sleeve depth & units	Describes monumentation quality.
setting code & specific setting text	Describes monumentation quality.
photograph (of marker)	Aids in station recovery.

OPTIONAL DATA ELEMENTS (11 each):

ELEMENT	RATIONALE
photographs (of equipment, horizon)	Equipment photos describe antenna height and equipment used. Horizon photos aid in station recovery and could explain visibility or multipath problems.
vertical stability code	Useful for stability assessment.
magnetic property code	Aids in station recovery.
antenna s/n	Useful in identifying equipment-specific problems.
receiver	Useful in identifying equipment-specific problems.
receiver s/n	Useful in identifying equipment-specific problems.
receiver firmware	Useful in identifying firmware-specific problems.
stamping	Aids in station identification.
condition code	Useful for stability assessment.
special application codes	Identifies the station type (tidal station, Public Land Survey corner, etc.)
remarks	Allows user to record observation comments.

This information regarding the Required Data Elements and Optional Data Elements is for reference only and not required at the present time. These requirements will be active once OPUS DB is designated operational by NGS. Out of the 15 Required Data Elements, 13 are applicable to all the marks and the remaining two - rod/pipe depth & units and sleeve depth & units – are applicable only to rod marks.

4.2.14. NAVD 88 GPS Tie

The NAVD 88 GPS tie involves simultaneous GPS observations at the GPSBM and one or more GBMs located up to 10 KM (6.26 mi) from the GPSBM. This “Height Mod” tie is deferred until such time as NGS enables user-friendly bluebooking of campaign data (OPUS projects).

4.3. Data Processing and Reduction**4.3.1. Data Quality Control**

The required output product used in generation of tide reducers and for tidal datum determination is a continuous time series of 6-minute interval water level data for the desired time period of hydrography and for a specified minimum time period from which to derive tidal datums. CO-OPS will monitor the installed system operation information for all gauges equipped with GOES satellite radios. The 6-minute interval water level data from the water level gauges shall be quality controlled to NOS standards by the contractor for invalid and suspect data as a final review prior to product generation and application. This includes checking for data gaps, data discontinuities, datum shifts, anomalous data points, data points outside of expected tolerances such as expected maximum and minimum values and for anomalous trends in the elevations due to sensor drift or vertical movement of the tide station components and bench marks.

Quality control shall include comparisons with simultaneous data from backup gauges, predicted tides or data from nearby stations, as appropriate. Data editing and gap filling shall use documented mathematically sound algorithms and procedures and an audit trail shall be used to track all changes and edits to observed data. All inferred data shall be appropriately flagged. Water level measurements from each station shall be related to a single, common datum, referred to as Station Datum. Station Datum is an arbitrary datum and should not be confused with a tidal datum such as MLLW. All discontinuities, jumps, or other changes in the gauge record (refer to the specific gauge user's guide) that may be due to vertical movement of any the gauge, staff, or bench marks shall be fully documented. All data shall be recorded on UTC and the units of measurement shall be properly denoted on all hard-copy output and digital files. Refer to Section 4.6 Data Submission Requirements for details.

4.3.2. Data Processing and Tabulation of the Tide

The continuous 6-minute interval water level data are used to generate the standard tabulation output products. These products include the times and heights of the high and low waters, hourly heights, maximum and minimum monthly water levels, and monthly mean values for the desired parameters. Examples of these tabulation products are found in Figure 4.3 and 4.4 for tide stations and 4.5 for Great Lakes stations. The times and heights of the high and low waters shall be derived from appropriate curve-fitting of the 6-minute interval data. For purposes of tabulation of the high and low tides and not non-tidal high frequency noise, successive high and low tides shall not be tabulated unless they are greater than 2.0 hours apart in time and 0.030 meters different in elevation. Hourly heights shall be derived from every 6-minute value observed on the hour. Monthly mean sea level and monthly mean water level shall be computed from the average of the hourly heights over each calendar month of data. Data shall be tabulated relative to a documented consistent station datum such as tide staff zero, arbitrary station datum, MLLW, etc.. over the duration of the data observations. Descriptions of general procedures used in tabulation are also found in the *Tide and Current Glossary, Manual of Tide Observations, and Tidal Datum Planes*.

4.3.3. Computation of Monthly Means

Monthly means are derived on a calendar month basis in accordance with the definitions for the monthly mean parameters as found in the Tide and Current Glossary. Examples of the desired monthly means are found in Figure 4.7. For purposes of monthly mean computation, monthly means shall not be computed if gaps in data are greater than three consecutive days.

4.3.4. Data Editing and Gap Filling Specifications

When backup sensor data are not available, data gaps in 6-minute data shall not be filled if the gaps are greater than three consecutive days in length. Data gap filling shall use documented mathematically and scientifically sound algorithms and procedures and an audit trail shall be used to track all gap-fills in observed data. Data gaps of less than 3-hours can be inferred using interpolation and curve-fitting techniques. Data gaps of longer than three hours shall use external data sources such as data from a nearby station. All data derived through gap-filling procedures shall be marked as inferred. Individual hourly heights, high and low waters, and daily means derived from inferred data shall also be designated as inferred.

Jan 31 2007 14:09 HIGH/LOW WATER LEVEL DATA July, 1998
 National Ocean Service (NOAA)

Station: 9414290 T.M.: 0 W
 Name: SAN FRANCISCO, SAN FRANCISCO BAY, CA Units: Meters
 Type: Mixed Datum: STND
 Note: > Higher-High/Lower-Low [] Inferred Tide Quality: Verified

High			Low			High			Low		
Day	Time	Height	Time	Height	Day	Time	Height	Time	Height		
1	> 1.4	3.337	6.8	2.521	16	> 0.6	3.550	6.2	2.343		
	12.6	2.996	> 18.5	2.253		12.6	3.187	> 18.1	2.195		
2	> 2.0	3.393	7.8	2.434	17	> 1.4	3.654	7.4	2.205		
	13.9	2.950	> 19.4	2.406		14.1	3.096	19.0	2.335		
3	> 2.6	3.458	> 9.1	2.367	18	> 2.2	3.725	> 8.6	2.054		
	15.2	2.941	20.1	2.498		15.6	3.132	20.2	2.504		
4	> 3.2	3.524	> 9.7	2.210	19	> 3.1	3.819	> 9.7	1.891		
	16.5	2.988	21.1	2.612		16.9	3.188	21.5	2.586		
5	> 4.0	3.584	> 10.3	2.018	20	> 4.1	3.899	> 10.7	1.763		
	17.6	3.054	22.0	2.644		18.0	3.267	22.5	2.597		
6	> 4.6	3.656	> 11.1	1.913	21	> 4.9	3.903	> 11.6	1.654		
	18.3	3.124	22.7	2.682		18.8	3.309	23.4	2.583		
7	> 5.1	3.711	> 11.8	1.812	22	> 6.0	3.884				
	19.1	3.194	23.4	2.697		19.6	3.347	> 12.4	1.587		
8	> 5.8	3.754			23	> 6.4	3.880	0.2	2.587		
	19.7	3.223	> 12.4	1.730		20.3	3.390	> 13.1	1.611		
9	> 6.3	3.789	0.1	2.703	24	> 7.4	3.833	1.1	2.586		
	20.4	3.285	> 13.1	1.669		20.9	3.409	> 13.9	1.659		
10	> 7.3	3.795	0.9	2.709	25	> 8.1	3.780	1.7	2.562		
	21.1	3.306	> 13.7	1.627		21.6	3.445	> 14.5	1.719		
11	> 8.0	3.712	1.6	2.614	26	> 8.7	3.668	2.6	2.564		
	21.7	3.302	> 14.4	1.579		22.2	3.437	> 14.9	1.826		
12	> 8.8	3.639	2.5	2.584	27	> 9.3	3.510	3.2	2.549		
	22.3	3.356	> 15.1	1.609		> 22.8	3.416	> 15.6	1.932		
13	> 9.3	3.547	3.1	2.530	28	10.1	3.356	4.1	2.538		
	23.1	3.419	> 15.6	1.692		> 23.5	3.430	> 16.1	2.042		
14	10.1	3.443	4.1	2.522	29	10.9	3.202	5.0	2.495		
	> 23.9	3.484	> 16.5	1.800				> 16.6	2.199		
15	11.3	3.282	5.1	2.422	30	> 0.1	3.432	5.9	2.492		
			> 17.0	1.967		12.0	3.099	> 17.3	2.402		
					31	> 0.8	3.472	> 6.9	2.431		
						13.1	3.018	18.5	2.513		

Highest Tide: 3.903 4.9 Hrs Jul 21 1998
 Lowest Tide: 1.579 14.4 Hrs Jul 11 1998

Monthly Means:

MHHW	3.641						
MHW	3.433	DHQ	0.208				
MTL	2.832			GT	1.720	HWI	7.57 Hrs
DTL	2.781			MN	1.203	LWI	0.76 Hrs
MSL	2.816						
MLW	2.230	DLQ	0.309				
MLLW	1.921						

Figure 4.3. High and Low Water Level Data

HOURLY WATER LEVELS

National Ocean Service (NOAA)

July 1998

Water Level Heights in meters on Station Datum

Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY , CA																
Time Meridian											0 W		Tide Type: Mixed			
HOURL	Jul 1	Jul 2	Jul 3	Jul 4	Jul 5	Jul 6	Jul 7	Jul 8	Jul 9	Jul 10	Jul 11	Jul 12	Jul 13	Jul 14	Jul 15	Jul 16
00	3.247	3.183	3.119	3.052	2.936	2.837	2.770	2.724	2.717	2.763	2.814	2.960	3.152	3.354	3.481	3.529
01	3.329	3.333	3.319	3.274	3.157	3.066	2.972	2.851	2.762	2.694	2.637	2.723	2.901	3.162	3.365	3.517
02	3.311	3.391	3.449	3.437	3.378	3.293	3.173	3.060	2.913	2.799	2.627	2.602	2.653	2.868	3.123	3.395
03	3.164	3.312	3.463	3.526	3.526	3.504	3.423	3.298	3.171	2.988	2.750	2.618	2.529	2.621	2.792	3.103
04	2.948	3.158	3.338	3.469	3.595	3.629	3.617	3.555	3.420	3.261	2.985	2.755	2.606	2.523	2.523	2.741
05	2.725	2.914	3.091	3.304	3.474	3.628	3.714	3.707	3.652	3.519	3.247	3.012	2.757	2.576	2.423	2.459
06	2.558	2.651	2.811	3.012	3.209	3.430	3.640	3.740	3.782	3.711	3.508	3.252	2.986	2.745	2.472	2.302
07	2.528	2.451	2.531	2.651	2.833	3.112	3.342	3.580	3.746	3.785	3.668	3.485	3.217	2.954	2.619	2.399
08	2.581	2.453	2.387	2.366	2.448	2.653	2.915	3.225	3.496	3.677	3.715	3.628	3.433	3.155	2.804	2.480
09	2.648	2.510	2.375	2.228	2.133	2.243	2.435	2.701	3.060	3.348	3.540	3.626	3.535	3.354	2.997	2.651
10	2.778	2.568	2.400	2.229	2.017	1.994	2.057	2.236	2.477	2.819	3.159	3.410	3.510	3.444	3.185	2.870
11	2.890	2.696	2.494	2.280	2.057	1.909	1.859	1.919	2.081	2.327	2.576	2.970	3.257	3.389	3.283	3.040
12	2.976	2.813	2.643	2.431	2.159	1.972	1.826	1.719	1.774	1.922	2.101	2.422	2.818	3.165	3.248	3.162
13	2.995	2.917	2.750	2.581	2.327	2.124	1.913	1.756	1.674	1.667	1.781	2.000	2.350	2.735	3.051	3.175
14	2.904	2.945	2.897	2.760	2.559	2.338	2.117	1.908	1.744	1.633	1.588	1.706	1.946	2.305	2.737	3.069
15	2.742	2.903	2.922	2.898	2.778	2.611	2.387	2.154	1.944	1.759	1.625	1.612	1.732	1.965	2.365	2.831
16	2.505	2.783	2.909	2.986	2.937	2.862	2.683	2.455	2.260	2.014	1.791	1.690	1.697	1.794	2.053	2.492
17	2.359	2.594	2.814	2.976	3.040	3.034	2.954	2.786	2.585	2.366	2.084	1.911	1.852	1.854	1.971	2.258
18	2.250	2.473	2.649	2.915	3.028	3.137	3.124	3.015	2.936	2.739	2.449	2.242	2.074	1.986	2.020	2.177
19	2.272	2.401	2.550	2.773	2.960	3.099	3.190	3.187	3.141	3.021	2.814	2.618	2.419	2.256	2.193	2.269
20	2.336	2.413	2.484	2.647	2.812	2.990	3.149	3.215	3.271	3.239	3.094	2.975	2.797	2.595	2.462	2.415
21	2.508	2.514	2.527	2.637	2.690	2.843	2.999	3.128	3.251	3.310	3.275	3.220	3.131	2.954	2.781	2.677
22	2.736	2.685	2.631	2.636	2.634	2.709	2.835	2.982	3.130	3.233	3.280	3.369	3.339	3.242	3.104	2.961
23	2.965	2.912	2.814	2.752	2.703	2.700	2.688	2.779	2.916	3.063	3.177	3.322	3.422	3.417	3.336	3.284
Mean	2.761	2.791	2.807	2.826	2.808	2.822	2.824	2.820	2.829	2.819	2.762	2.755	2.755	2.767	2.766	2.802
[] denotes inferred water level values Data Status: Verified																
HOURL	Jul 17	Jul 18	Jul 19	Jul 20	Jul 21	Jul 22	Jul 23	Jul 24	Jul 25	Jul 26	Jul 27	Jul 28	Jul 29	Jul 30	Jul 31	
00	3.514	3.373	3.180	2.993	2.778	2.625	2.586	2.678	2.821	3.048	3.228	3.317	3.411	3.444	3.438	
01	3.654	3.617	3.485	3.264	3.035	2.810	2.649	2.586	2.613	2.749	2.951	3.122	3.270	3.357	3.466	
02	3.620	3.720	3.720	3.573	3.322	3.071	2.848	2.682	2.573	2.590	2.680	2.834	3.030	3.195	3.394	Monthly
03	3.427	3.686	3.818	3.785	3.641	3.379	3.133	2.884	2.694	2.576	2.550	2.625	2.735	2.937	3.148	Max HWL
04	3.111	3.433	3.737	3.907	3.840	3.659	3.444	3.201	2.926	2.761	2.591	2.538	2.547	2.704	2.888	04:54/21
05	2.704	3.048	3.487	3.775	3.898	3.849	3.697	3.460	3.206	2.978	2.759	2.586	2.487	2.523	2.660	3.903
06	2.398	2.607	3.017	3.452	3.745	3.887	3.866	3.717	3.505	3.247	2.976	2.757	2.553	2.486	2.467	
07	2.215	2.254	2.539	2.948	3.376	3.678	3.851	3.828	3.704	3.501	3.210	2.928	2.697	2.545	2.448	
08	2.255	2.073	2.167	2.436	2.810	3.269	3.593	3.770	3.778	3.652	3.390	3.150	2.860	2.659	2.477	Monthly
09	2.319	2.064	1.953	2.018	2.299	2.662	3.083	3.430	3.637	3.659	3.504	3.302	3.031	2.809	2.571	Min LWL
10	2.483	2.155	1.884	1.806	1.896	2.146	2.526	2.942	3.284	3.486	3.479	3.358	3.144	2.948	2.725	14:24/11
11	2.691	2.304	1.993	1.757	1.696	1.794	2.071	2.397	2.758	3.107	3.252	3.294	3.203	3.055	2.856	1.579
12	2.876	2.544	2.195	1.877	1.664	1.603	1.743	1.981	2.282	2.618	2.907	3.090	3.119	3.107	2.975	
13	3.037	2.784	2.453	2.094	1.808	1.637	1.621	1.723	1.924	2.215	2.471	2.741	2.953	3.037	3.031	
14	3.088	2.995	2.738	2.387	2.076	1.816	1.662	1.644	1.740	1.919	2.149	2.402	2.658	2.905	2.975	Monthly
15	3.038	3.104	2.978	2.738	2.434	2.122	1.918	1.797	1.762	1.827	1.956	2.144	2.396	2.676	2.908	Mean
16	2.880	3.119	3.134	3.028	2.790	2.510	2.249	2.056	1.942	1.882	1.950	2.016	2.231	2.493	2.725	MSL
17	2.621	3.011	3.191	3.220	3.078	2.887	2.646	2.422	2.219	2.117	2.061	2.118	2.218	2.398	2.595	2.816
18	2.400	2.812	3.107	3.284	3.266	3.162	3.018	2.791	2.604	2.412	2.302	2.244	2.299	2.432	2.508	
19	2.323	2.600	2.938	3.179	3.300	3.316	3.273	3.162	2.978	2.775	2.615	2.496	2.465	2.490	2.527	
20	2.402	2.513	2.731	3.013	3.210	3.336	3.394	3.345	3.271	3.109	2.939	2.795	2.688	2.663	2.620	
21	2.554	2.550	2.605	2.755	3.012	3.214	3.345	3.401	3.415	3.335	3.215	3.075	2.963	2.884	2.766	
22	2.789	2.698	2.619	2.612	2.735	2.975	3.189	3.316	3.427	3.428	3.369	3.310	3.184	3.109	2.984	
23	3.073	2.920	2.760	2.631	2.613	2.707	2.912	3.118	3.300	3.400	3.407	3.429	3.373	3.308	3.178	
Mean	2.811	2.833	2.851	2.855	2.847	2.838	2.847	2.847	2.848	2.850	2.830	2.820	2.813	2.840	2.847	

Figure 4.4. Hourly Height Water Level Data for a Tide Station

HOURLY WATER LEVELS

National Ocean Service (NOAA)

July 1998

Water Level Heights in meters IGLD (1985)

Station: 9052030 Oswego, Lake Ontario , NY										Time Meridian: 75 W		Data Type: Great Lakes					
HOURL	Jul 1	Jul 2	Jul 3	Jul 4	Jul 5	Jul 6	Jul 7	Jul 8	Jul 9	Jul 10	Jul 11	Jul 12	Jul 13	Jul 14	Jul 15	Jul 16	
01	75.21	75.21	75.19	75.18	75.19	75.17	75.15	75.17	75.17	75.20	75.21	75.21	75.20	75.17	75.17	75.17	
02	75.25	75.21	75.19	75.19	75.22	75.14	75.17	75.16	75.19	75.19	75.20	75.22	75.18	75.17	75.18	75.16	
03	75.26	75.21	75.19	75.17	75.19	75.18	75.18	75.16	75.16	75.19	75.21	75.19	75.18	75.18	75.15	75.17	
04	75.25	75.20	75.19	75.20	75.21	75.18	75.17	75.16	75.17	75.20	75.21	75.18	75.17	75.18	75.16	75.16	
05	75.25	75.21	75.20	75.19	75.21	75.18	75.17	75.20	75.20	75.18	75.21	75.20	75.19	75.17	75.19	75.16	
06	75.25	75.21	75.19	75.20	75.20	75.19	75.17	75.16	75.19	75.20	75.20	75.20	75.17	75.17	75.14	75.15	
07	75.25	75.20	75.19	75.19	75.19	75.17	75.18	75.20	75.20	75.19	75.21	75.20	75.18	75.17	75.14	75.17	
08	75.24	75.21	75.19	75.21	75.20	75.17	75.17	75.14	75.19	75.20	75.22	75.20	75.19	75.15	75.18	75.15	
09	75.24	75.21	75.19	75.20	75.19	75.19	75.16	75.17	75.18	75.18	75.22	75.20	75.19	75.18	75.16	75.14	
10	75.24	75.20	75.19	75.18	75.19	75.18	75.16	75.20	75.17	75.20	75.22	75.22	75.18	75.18	75.17	75.16	
11	75.23	75.19	75.17	75.18	75.20	75.18	75.15	75.15	75.19	75.20	75.22	75.20	75.19	75.18	75.16	75.15	
12	75.22	75.21	75.18	75.18	75.17	75.17	75.17	75.16	75.17	75.19	75.22	75.20	75.18	75.18	75.17	75.16	
13	75.22	75.20	75.18	75.19	75.18	75.16	75.16	75.15	75.17	75.18	75.21	75.19	75.19	75.17	75.16	75.16	
14	75.23	75.20	75.19	75.21	75.18	75.19	75.14	75.15	75.16	75.18	75.20	75.22	75.17	75.17	75.18	75.17	
15	75.22	75.21	75.17	75.19	75.17	75.15	75.14	75.18	75.17	75.19	75.20	75.18	75.18	75.17	75.17	75.17	
16	75.21	75.20	75.19	75.18	75.19	75.16	75.18	75.18	75.17	75.19	75.19	75.19	75.17	75.16	75.16	75.16	
17	75.21	75.20	75.20	75.21	75.20	75.17	75.17	75.18	75.17	75.19	75.20	75.18	75.17	75.17	75.17	75.15	
18	75.22	75.20	75.20	75.21	75.21	75.20	75.18	75.18	75.15	75.17	75.20	75.18	75.16	75.15	75.16	75.16	
19	75.21	75.20	75.19	75.21	75.19	75.19	75.18	75.20	75.18	75.22	75.19	75.19	75.17	75.16	75.16	75.17	
20	75.20	75.22	75.19	75.25	75.19	75.17	75.18	75.18	75.20	75.22	75.20	75.20	75.16	75.16	75.16	75.13	
21	75.20	75.18	75.18	75.15	75.19	75.19	75.15	75.19	75.22	75.18	75.21	75.19	75.18	75.16	75.15	75.17	
22	75.21	75.20	75.17	75.17	75.19	75.18	75.19	75.17	75.23	75.20	75.21	75.19	75.18	75.18	75.15	75.13	
23	75.20	75.19	75.17	75.24	75.19	75.16	75.18	75.19	75.22	75.22	75.21	75.17	75.18	75.16	75.17	75.13	
24	75.21	75.20	75.17	75.20	75.18	75.17	75.17	75.19	75.18	75.21	75.21	75.18	75.18	75.15	75.16	75.15	
Mean	75.23	75.20	75.19	75.19	75.19	75.18	75.17	75.17	75.18	75.20	75.21	75.19	75.18	75.17	75.16	75.16	
HOURL	Jul 17	Jul 18	Jul 19	Jul 20	Jul 21	Jul 22	Jul 23	Jul 24	Jul 25	Jul 26	Jul 27	Jul 28	Jul 29	Jul 30	Jul 31		
01	75.17	75.17	75.14	75.12	75.13	75.14	75.11	75.16	75.14	75.11	75.09	75.07	75.07	75.10	75.09		
02	75.17	75.18	75.14	75.16	75.12	75.16	75.12	75.16	75.14	75.10	75.08	75.09	75.06	75.11	75.08		
03	75.16	75.19	75.15	75.15	75.11	75.16	75.12	75.15	75.13	75.10	75.08	75.06	75.06	75.10	75.08	Monthly	
04	75.17	75.18	75.14	75.14	75.13	75.15	75.10	75.14	75.14	75.10	75.07	75.09	75.02	75.09	75.08	Max HWL	
05	75.16	75.18	75.16	75.13	75.14	75.13	75.14	75.16	75.13	75.10	75.06	75.11	75.07	75.08	75.08	03:00/01	
06	75.17	75.16	75.15	75.16	75.10	75.17	75.12	75.16	75.12	75.10	75.06	75.07	75.16	75.07	75.08	75.259	
07	75.16	75.16	75.17	75.14	75.12	75.13	75.14	75.14	75.13	75.10	75.07	75.06	75.14	75.07	75.07		
08	75.16	75.16	75.14	75.15	75.15	75.12	75.14	75.16	75.13	75.10	75.06	75.08	75.11	75.05	75.07		
09	75.15	75.15	75.11	75.14	75.12	75.20	75.15	75.17	75.13	75.11	75.06	75.06	75.10	75.08	75.07	Monthly	
10	75.16	75.15	75.11	75.14	75.11	75.18	75.10	75.15	75.13	75.12	75.08	75.07	75.11	75.07	75.06	Min LWL	
11	75.16	75.16	75.13	75.14	75.11	75.16	75.11	75.16	75.12	75.11	75.08	75.06	75.11	75.06	75.07	04:00/29	
12	75.16	75.17	75.16	75.14	75.12	75.12	75.13	75.14	75.11	75.11	75.09	75.07	75.12	75.10	75.07	75.021	
13	75.16	75.15	75.14	75.14	75.12	75.14	75.13	75.14	75.11	75.10	75.07	75.05	75.08	75.08	75.07		
14	75.16	75.17	75.13	75.15	75.10	75.11	75.14	75.14	75.10	75.11	75.06	75.08	75.08	75.08	75.06		
15	75.17	75.16	75.13	75.13	75.12	75.12	75.12	75.13	75.11	75.09	75.07	75.06	75.07	75.08	75.05	Monthly	
16	75.16	75.16	75.13	75.13	75.13	75.14	75.14	75.13	75.12	75.09	75.08	75.05	75.09	75.05	75.06	Mean	
17	75.18	75.16	75.13	75.13	75.08	75.11	75.16	75.13	75.10	75.07	75.08	75.07	75.08	75.09	75.06	MSL	
18	75.17	75.15	75.14	75.16	75.12	75.13	75.13	75.13	75.10	75.07	75.08	75.06	75.08	75.09	75.06	75.152	
19	75.16	75.16	75.13	75.14	75.11	75.11	75.10	75.14	75.10	75.08	75.06	75.05	75.07	75.09	75.06		
20	75.17	75.16	75.16	75.15	75.12	75.13	75.16	75.14	75.11	75.09	75.06	75.07	75.09	75.07	75.06		
21	75.18	75.14	75.11	75.13	75.16	75.12	75.17	75.14	75.11	75.08	75.07	75.05	75.09	75.07	75.04		
22	75.18	75.15	75.14	75.13	75.10	75.15	75.17	75.14	75.11	75.08	75.07	75.06	75.09	75.08	75.06		
23	75.18	75.14	75.14	75.12	75.09	75.14	75.18	75.14	75.11	75.08	75.09	75.05	75.10	75.08	75.05		
24	75.19	75.14	75.11	75.11	75.09	75.12	75.17	75.15	75.11	75.09	75.10	75.08	75.09	75.09	75.06		
Mean	75.17	75.16	75.14	75.14	75.12	75.14	75.14	75.15	75.12	75.10	75.07	75.07	75.09	75.08	75.07		

[] denotes inferred water level values Data Status: Verified

Figure 4.5. Hourly Height Water Level Data for a Great Lakes Station

4.4. Computation of Tidal Datums and Water Level Datums

4.4.1. National Tidal Datum Epoch

Tidal datums must be computed relative to a specific 19 year tidal cycle adopted by the National Ocean Service (NOS) called the National Tidal Datum Epoch (NTDE). The present NTDE is the period 1983 through 2001. A primary datum determination is based directly on the average of tide observations over the 19 year Epoch period at NOS permanent long term primary control stations in the National Water Level Observation Network (NWLON). The data from NOS primary stations are used to compute datums at short term subordinate stations by reducing the data from those subordinate stations to equivalent 19 year mean values through the method of comparison of simultaneous observation.

4.4.2. Computational Procedures

The equivalent 19 year tidal datums for subordinate stations are computed for certain phases of the tide using tide-by-tide comparisons or monthly mean comparisons with an appropriate NOS long term control station. Accepted 19 year mean values of mean tide level (MTL), mean range (Mn), diurnal high water inequality (DHQ), diurnal low water inequality (DLQ), diurnal tide level (DTL), and great diurnal range (Gt) are required in the reduction process in which a “short series” of tide observations at any location are compared with simultaneous observations from an NOS control station. Datums are computed by the “standard” method of range ratio comparison generally on the West coast and Pacific Islands where there exists a large diurnal inequality in the low and high waters. The “modified” method of range ratio comparison is generally used on the East coast and Caribbean where small differences exist in the low and high water diurnal inequalities. For stations requiring a datum determination, at least 30 continuous days of tide observations are required for stations where adequate primary datum control exists. For error budget purposes, one month of data results in a datum accuracy of 0.11 m (95% confidence level) for Stations in the Gulf of Mexico and 0.08 m (95% confidence level) for east and West Coast stations. Examples of a tide by tide and a monthly mean simultaneous comparison for datum determination are found in Figures 4.6 and 4.7. Descriptions of the tidal datum computational procedures are found in the *Tide and Current Glossary*, *Tidal Datum Planes*, *Manual of Tide Observations*, *NOAA Special Publication NOS CO-OPS 1Tidal Datums and Their Applications and Computational Techniques for Tidal Datums*.

4.4.3. Tidal Datum Recovery

Whenever tide stations are installed at historical sites, measures shall be taken to “recover” the established tidal datums through leveling which shall be accomplished by referencing the gauge or tide staff zero “0” to more than one existing bench mark (three bench marks are preferred) with a published tidal elevation. Through this process, the published MLLW elevation is transferred by level differences to the “new” gauge or tide staff and compared to the MLLW elevation computed from the new data on the same zero “0”. Factors affecting the datum recovery (i.e. differences between old and newly computed datums) include the length of each data series used to compute the datums, the geographical location, the tidal characteristics in the region, the length of time between reoccupations, the sea level trends in the region, and the control station used. Based on all of these factors, the datum recovery can be expected to vary from +/- 0.03 m to +/- 0.08 m. Hence, this process also serves as a very useful quality control procedure. After a successful datum recovery is performed and benchmark stability is established, the historical value of Mean Lower Low Water (MLLW) shall be used as the operational datum reference for data from the gauge during hydrographic survey operations. An example of a published tidal datum sheet for a station for which a datum recovery could be made is found in Figure 4.8.

Begin: Jun 15 2005 00:00
 End: Jul 14 2005 23:54
 Run: Jan 31 2007 16:30

COMPARISON OF SIMULTANEOUS OBSERVATIONS

Tidal Epoch: 1983-2001
 Expected Diff: 0.55 Hrs
 * Exceeds 2 Standard Dev

(A) Subordinate Station: 9414863 RICHMOND, CHEVRON OIL PIER
 (B) Standard Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY

Verified T.M.: OW Tide Type: Mixed
 Verified T.M.: OW Tide Type: Mixed

(A) STATION Time of				(B) STATION Time of				(A) - (B) Time Difference		(A) STATION Height of		(B) STATION Height of		(A) - (B) Height Difference	
2005	HW Hour	Date	LW Hour	Date	HW Hour	Date	LW Hour	Hours	Hours	Meters	Meters	Meters	Meters	Meters	Meters
Jun 15	2.3 HH	Jun 15	8.4 L	Jun 15	2.0 HH	Jun 15	7.5 L	0.3	0.9	5.091	4.266	3.304	2.546	1.787	1.720
Jun 15	13.6 H	Jun 15	19.7 LL	Jun 15	13.2 H	Jun 15	19.0 LL	0.4	0.7	4.745	3.890	2.970	2.222	1.775	1.668*
Jun 16	3.0 HH	Jun 16	9.3 L	Jun 16	2.5 HH	Jun 16	8.4 L	0.5	0.9	5.193	4.065	3.412	2.362	1.781	1.703
Jun 16	15.0 H	Jun 16	20.5 L	Jun 16	14.6 H	Jun 16	19.7 L	0.4	0.8	4.731	4.070	2.953	2.350	1.778	1.720
Jun 17	3.4 HH	Jun 17	10.0 LL	Jun 17	3.0 HH	Jun 17	9.1 LL	0.4	0.9	5.347	3.861	3.566	2.144	1.781	1.717
Jun 17	16.1 H	Jun 17	21.4 L	Jun 17	15.7 H	Jun 17	20.6 L	0.4	0.8	4.736	4.140	2.960	2.418	1.776	1.722
Jun 18	4.0 HH	Jun 18	10.8 LL	Jun 18	3.5 HH	Jun 18	10.1 LL	0.5	0.7	5.400	3.657	3.612	1.919	1.788	1.738
Jun 18	17.4 H	Jun 18	22.2 L	Jun 18	17.0 H	Jun 18	21.6 L	0.4	0.6	4.793	4.265	3.015	2.539	1.778	1.726
Jun 19	4.5 HH	Jun 19	11.8 LL	Jun 19	4.1 HH	Jun 19	11.1 LL	0.4	0.7	5.528	3.440	3.728	1.714	1.800	1.726
Jun 19	18.6 H	Jun 19	23.0 L	Jun 19	18.1 H	Jun 19	22.4 L	0.5	0.6	4.833	4.365	3.057	2.626	1.776	1.739
Jun 20	5.2 HH	Jun 20	12.6 LL	Jun 20	5.0 HH	Jun 20	11.9 LL	0.2*	0.7	5.603	3.249	3.806	1.503	1.797	1.746
Jun 20	19.5 H	Jun 20	23.8 L	Jun 20	19.1 H	Jun 20	23.2 L	0.4	0.6	4.893	4.452	3.107	2.722	1.786	1.730
Jun 21	5.8 HH	Jun 21	13.4 LL	Jun 21	5.5 HH	Jun 21	12.9 LL	0.3	0.5	5.681	3.127	3.887	1.368	1.794	1.759
Jun 21	20.4 H	Jun 22	0.6 L	Jun 21	20.1 H	Jun 22	0.1 L	0.3	0.5	4.961	4.482	3.167	2.753	1.794	1.729
Jun 22	6.5 HH	Jun 22	14.2 LL	Jun 22	6.2 HH	Jun 22	13.6 LL	0.3	0.6	5.727	3.026	3.933	1.248	1.794	1.778
Jun 22	21.3 H	Jun 23	1.6 L	Jun 22	20.9 H	Jun 23	1.0 L	0.4	0.6	4.984	4.498	3.192	2.766	1.792	1.732
Jun 23	7.6 HH	Jun 23	15.0 LL	Jun 23	7.2 HH	Jun 23	14.4 LL	0.4	0.6	5.736	2.999	3.936	1.230	1.800	1.769
Jun 23	22.1 H	Jun 24	2.5 L	Jun 23	21.7 H	Jun 24	1.9 L	0.4	0.6	5.024	4.476	3.230	2.755	1.794	1.721
Jun 24	8.2 HH	Jun 24	15.9 LL	Jun 24	7.8 HH	Jun 24	15.1 LL	0.4	0.8	5.711	3.054	3.935	1.307	1.776	1.747
Jun 24	22.9 H	Jun 25	3.5 L	Jun 24	22.3 H	Jun 25	2.9 L	0.6	0.6	5.084	4.436	3.309	2.714	1.775	1.722
Jun 25	9.2 HH	Jun 25	16.6 LL	Jun 25	8.8 HH	Jun 25	15.7 LL	0.4	0.9	5.615	3.164	3.839	1.415	1.776	1.749
Jun 25	23.7 H	Jun 26	4.5 L	Jun 25	23.1 H	Jun 26	4.0 L	0.6	0.5	5.165	4.387	3.394	2.678	1.771	1.709
Jun 26	10.3 HH	Jun 26	17.5 LL	Jun 26	9.9 HH	Jun 26	16.6 LL	0.4	0.9	5.453	3.316	3.674	1.577	1.779	1.739
Jun 27	0.4 H	Jun 27	5.7 L	Jun 26	23.7 HH	Jun 27	5.1 L	0.7*	0.6	5.243	4.299	3.477	2.579	1.766*	1.720
Jun 27	11.4 HH	Jun 27	18.1 LL	Jun 27	10.8 H	Jun 27	17.3 LL	0.6	0.8	5.257	3.478	3.467	1.744	1.790	1.734
Jun 28	1.2 HH	Jun 28	6.9 L	Jun 28	0.6 HH	Jun 28	6.4 L	0.6	0.5	5.313	4.167	3.538	2.451	1.775	1.716
Jun 28	12.6 H	Jun 28	18.7 LL	Jun 28	12.1 H	Jun 28	18.1 LL	0.5	0.6	5.007	3.639	3.217	1.921	1.790	1.718
Jun 29	1.9 HH	Jun 29	8.2 L	Jun 29	1.4 HH	Jun 29	7.5 L	0.5	0.7	5.381	3.997	3.591	2.274	1.790	1.723
Jun 29	14.0 H	Jun 29	19.5 LL	Jun 29	13.6 H	Jun 29	18.9 LL	0.4	0.6	4.883	3.908	3.094	2.210	1.789	1.698
Jun 30	2.6 HH	Jun 30	9.3 LL	Jun 30	2.1 HH	Jun 30	8.7 LL	0.5	0.6	5.486	3.850	3.711	2.119	1.775	1.731
Jun 30	15.6 H	Jun 30	20.6 L	Jun 30	15.2 H	Jun 30	20.1 L	0.4	0.5	4.824	4.151	3.047	2.445	1.777	1.706
Jul 1	3.3 HH	Jul 1	10.3 LL	Jul 1	2.9 HH	Jul 1	9.8 LL	0.4	0.5	5.521	3.694	3.741	1.957	1.780	1.737
Jul 1	17.1 H	Jul 1	21.8 L	Jul 1	16.7 H	Jul 1	21.2 L	0.4	0.6	4.867	4.347	3.083	2.625	1.784	1.722
Jul 2	4.2 HH	Jul 2	11.3 LL	Jul 2	3.7 HH	Jul 2	10.7 LL	0.5	0.6	5.554	3.565	3.768	1.816	1.786	1.749
Jul 2	18.4 H	Jul 2	22.7 L	Jul 2	17.9 H	Jul 2	22.2 L	0.5	0.5	4.943	4.500	3.152	2.770	1.791	1.730
Jul 3	4.7 HH	Jul 3	12.2 LL	Jul 3	4.3 HH	Jul 3	11.5 LL	0.4	0.7	5.590	3.464	3.809	1.712	1.781	1.752
Jul 3	19.4 H	Jul 3	23.5 L	Jul 3	18.9 H	Jul 3	23.1 L	0.5	0.4	4.963	4.519	3.180	2.797	1.783	1.722
Jul 4	5.6 HH	Jul 4	12.9 LL	Jul 4	5.1 HH	Jul 4	12.2 LL	0.5	0.7	5.571	3.379	3.782	1.637	1.789	1.742
Jul 4	20.1 H	Jul 5	0.4 L	Jul 4	19.6 H	Jul 4	23.9 L	0.5	0.5	5.016	4.579	3.230	2.853	1.786	1.726
Jul 5	6.0 HH	Jul 5	13.5 LL	Jul 5	5.5 HH	Jul 5	12.7 LL	0.5	0.8	5.540	3.354	3.751	1.598	1.789	1.756
Jul 5	20.9 H	Jul 6	1.2 L	Jul 5	20.3 H	Jul 6	0.6 L	0.6	0.6	5.029	4.598	3.244	2.861	1.785	1.737
Jul 6	6.9 HH	Jul 6	14.1 LL	Jul 6	6.3 HH	Jul 6	13.5 LL	0.6	0.6	5.521	3.354	3.734	1.601	1.787	1.753
Jul 6	21.5 H	Jul 7	1.9 L	Jul 6	20.9 H	Jul 7	1.3 L	0.6	0.6	5.056	4.584	3.272	2.860	1.784	1.724

Figure 4.6. Tide-By-Tide Comparison

Begin: Jun 15 2005 00:00
 End: Jul 14 2005 00:00
 Run: Jan 31 2007 16:30

COMPARISON OF SIMULTANEOUS OBSERVATIONS

Tidal Epoch: 1983-2001
 Expected Diff: 0.55 Hrs
 * Exceeds 2 Standard Dev

(A) Subordinate Station: 9414863 RICHMOND, CHEVRON OIL PIER
 (B) Standard Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY

Verified T. M.: OW Tide Type: Mixed
 Verified T. M.: OW Tide Type: Mixed

(A) STATION Time of				(B) STATION Time of				(A) - (B) Time Difference		(A) STATION Height of		(B) STATION Height of		(A) - (B) Height Difference	
2005	HW Hour	Date	LW Hour	Date	HW Hour	Date	LW Hour	HW Hours	LW Hours	Meters	Meters	Meters	Meters	Meters	Meters
Jul 7	7.4 HH	Jul 7	14.8 LL	Jul 7	7.2 HH	Jul 7	13.9 LL	0.2*	0.9	5.510	3.380	3.715	1.622	1.795	1.758
Jul 7	22.0 H	Jul 8	2.4 L	Jul 7	21.4 H	Jul 8	1.9 L	0.6	0.5	5.037	4.533	3.248	2.822	1.789	1.711
Jul 8	8.0 HH	Jul 8	15.3 LL	Jul 8	7.6 HH	Jul 8	14.5 LL	0.4	0.8	5.444	3.397	3.660	1.654	1.784	1.743
Jul 8	22.5 H	Jul 9	3.0 L	Jul 8	21.9 H	Jul 9	2.4 L	0.6	0.6	5.016	4.478	3.225	2.775	1.791	1.703
Jul 9	8.7 HH	Jul 9	15.8 LL	Jul 9	8.2 HH	Jul 9	15.1 LL	0.5	0.7	5.375	3.453	3.587	1.719	1.788	1.734
Jul 9	23.1 H	Jul 10	3.7 L	Jul 9	22.5 H	Jul 10	3.2 L	0.6	0.5	5.036	4.462	3.245	2.760	1.791	1.702
Jul 10	9.5 HH	Jul 10	16.2 LL	Jul 10	8.9 HH	Jul 10	15.5 LL	0.6	0.7	5.267	3.541	3.476	1.802	1.791	1.739
Jul 10	23.6 H	Jul 11	4.5 L	Jul 10	23.1 H	Jul 11	4.0 L	0.5	0.5	5.059	4.432	3.260	2.728	1.799	1.704
Jul 11	9.9 HH	Jul 11	16.8 LL	Jul 11	9.5 HH	Jul 11	16.0 LL	0.4	0.8	5.153	3.622	3.365	1.900	1.788	1.722
Jul 12	0.1 H	Jul 12	5.5 L	Jul 11	23.7 H	Jul 12	4.9 L	0.4	0.6	5.110	4.359	3.325	2.651	1.785	1.708
Jul 12	10.8 H	Jul 12	17.2 LL	Jul 12	10.4 H	Jul 12	16.5 LL	0.4	0.7	4.992	3.705	3.211	1.998	1.781	1.707
Jul 13	0.6 HH	Jul 13	6.3 L	Jul 13	0.1 HH	Jul 13	5.8 L	0.5	0.5	5.155	4.294	3.362	2.565	1.793	1.729
Jul 13	11.7 H	Jul 13	17.8 LL	Jul 13	11.3 H	Jul 13	17.1 LL	0.4	0.7	4.875	3.899	3.090	2.204	1.785	1.695
										HHW	HLW	HHW	HLW	HHW	HLW
										152.709	122.201	102.699	74.045	50.010	48.156
										SUMS ITEMS MEANS STD DEV	28 28 5.454 4.364	28 28 3.668 2.644	28 28 1.786 0.007	28 28 1.720 0.011	
										LHW	LLW	LHW	LLW	LHW	LLW
										25.60 56 0.46 0.11	36.50 56 0.65 0.13	138.919 28 4.961	97.465 28 3.481	88.944 28 3.177	48.861 28 1.745
										SUMS ITEMS MEANS STD DEV	56 28 0.46 0.11	56 28 0.65 0.13	56 28 1.785 0.008	56 28 1.736 0.024	

Figure 4.6. Tide-By-Tide Comparison (continued)

Begin: Jun 15 2005 00:00
 End: Jul 14 2005 00:00
 Run: Jan 31 2007 16:30

COMPARISON OF SIMULTANEOUS OBSERVATIONS

Tidal Epoch: 1983-2001
 Expected Diff: 0.55 Hrs
 * Exceeds 2 Standard Dev

(A) Subordinate Station: 9414863 RICHMOND, CHEVRON OIL PIER
 (B) Standard Station: 9414290 SAN FRANCISCO, SAN FRANCISCO BAY

Verified T.M.: OW Tide Type: Mixed
 Verified T.M.: OW Tide Type: Mixed

Mean Difference in HWI: 0.46
 Mean HHW Height at (A): 5.454
 Mean LHW Height at (A): 4.961
 DHQ at (A): 0.246
 Mean HW Height at (A): 5.208
 MN at (A): 1.285
 GT at (A): 1.973

Mean Difference in LWI: 0.65
 Mean HLW Height at (A): 4.364
 Mean LLW Height at (A): 3.481
 DLQ at (A): 0.442
 Mean LW Height at (A): 3.923
 MTL at (A): 4.565
 DTL at (A): 4.467

Mean HHW Difference: 1.786
 Mean LHW Difference: 1.785
 DHQ Difference: 0.001
 Mean HW Difference: 1.785
 MN Difference: 0.058
 GT Difference: 0.050
 MN Ratio: 1.047
 GT Ratio: 1.026
 MSL (100.00%) at (A): 4.548
 MSL (100.00%) at (B): 2.782
 MSL Difference: 1.766

Mean HLW Difference: 1.720
 Mean LLW Difference: 1.736
 DLQ Difference: -0.008
 Mean LW Difference: 1.728
 MTL Difference: 1.757
 DTL Difference: 1.761
 DHQ Ratio: 1.003
 DLQ Ratio: 0.982

	HWI	LWI	MTL	MN	MSL	DHQ	DLQ
	Hours	Hours	Meters	Meters	Meters	Meters	Meters
Accepted for B:	7.53	0.85	2.792	1.248	2.773	0.186	0.346
Differences and Ratios:	0.46	0.65	1.757	1.047	1.766	1.003	0.982
Corrected for A:	7.99	1.50	4.549	1.307	4.539	0.186	0.340

FINAL/PRELIMINARY DATUMS Standard Method

MHHW	---	---	5.388	DHQ	0.186
MHW	-	-	5.202		
DTL	-	-	4.472		
MTL	-	-	4.549	GT	1.833
MSL	-	-	4.539	MN	1.307
MLW	-	-	3.895	DLQ	0.340
MLLW	---	---	3.555		

On Staff Of:

HWI: 7.99
 LWI: 1.50

Date _____ ID _____
 Comparison _____
 Verified _____

Figure 4.6. Tide-By-Tide Comparison (concluded)

COMPARISON OF MONTHLY MEANS (Jan 2005 - Dec 2005)
1983-2001 TIDAL EPOCH

Feb 01, 2007

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAYProduct
ProductTM (OW) TIDE TYPE (M)
TM (OW) TIDE TYPE (M)

Mon Year	A	M T L	A - B	A	M S L	A - B	A	H W I	A - B	A	L W I	A - B	A	M N	A / B
	METER	METER	METER	METER	METER	METER	METER	HRS	HRS	HRS	HRS	HRS	METER	METER	RATIO
Jan 2005	4.665	2.900	1.765	4.650	2.876	1.774	7.890	7.450	0.440	1.380	0.750	0.630	1.293	1.212	1.067
Feb 2005	4.639	2.875	1.764	4.626	2.853	1.773	7.970	7.520	0.450	1.430	0.800	0.630	1.315	1.239	1.061
Mar 2005	4.593	2.813	1.780	4.575	2.791	1.784	7.890	7.450	0.440	1.320	0.690	0.630	1.288	1.207	1.067
Apr 2005	4.503	2.740	1.763	4.485	2.713	1.772	7.890	7.500	0.390	1.380	0.720	0.660	1.276	1.199	1.064
May 2005	4.563	2.805	1.758	4.542	2.773	1.769	7.890	7.480	0.410	1.430	0.720	0.710	1.281	1.209	1.060
Jun 2005	4.535	2.780	1.755	4.517	2.750	1.767	7.870	7.450	0.420	1.430	0.710	0.720	1.274	1.210	1.053
Jul 2005	4.607	2.856	1.751	4.590	2.826	1.764	7.950	7.490	0.460	1.460	0.840	0.620	1.284	1.231	1.043
Aug 2005	4.604	2.864	1.740	4.593	2.838	1.755	7.970	7.520	0.450	1.490	0.880	0.610	1.279	1.230	1.040
Sep 2005	4.571	2.838	1.733	4.565	2.819	1.746	7.880	7.460	0.420	1.420	0.830	0.590	1.273	1.225	1.039
Oct 2005		2.809			2.787			7.420			0.810			1.235	
Nov 2005		2.781			2.751			7.440			0.830			1.229	
Dec 2005		2.840			2.805			7.460			0.800			1.245	

Mon Year	A	D H Q	A / B	A	D L Q	A / B	A	M H W	A - B	A	M L W	A - B
	METER	METER	RATIO	METER	METER	RATIO	METER	METER	METER	METER	METER	METER
Jan 2005	0.227	0.224	1.013	0.401	0.406	0.988	5.312	3.506	1.806	4.019	2.294	1.725
Feb 2005	0.207	0.204	1.015	0.350	0.354	0.989	5.296	3.494	1.802	3.981	2.255	1.726
Mar 2005	0.154	0.152	1.013	0.329	0.324	1.015	5.237	3.417	1.820	3.949	2.210	1.739
Apr 2005	0.156	0.156	1.000	0.388	0.380	1.021	5.141	3.339	1.802	3.865	2.140	1.725
May 2005	0.179	0.179	1.000	0.431	0.427	1.009	5.204	3.409	1.795	3.923	2.200	1.723
Jun 2005	0.246	0.245	1.004	0.439	0.439	1.000	5.172	3.385	1.787	3.898	2.175	1.723
Jul 2005	0.258	0.257	1.004	0.429	0.441	0.973	5.249	3.471	1.778	3.965	2.240	1.725
Aug 2005	0.218	0.216	1.009	0.376	0.393	0.957	5.244	3.479	1.765	3.965	2.249	1.716
Sep 2005	0.161	0.156	1.032	0.305	0.324	0.941	5.207	3.451	1.756	3.934	2.226	1.708
Oct 2005		0.140			0.324			3.427			2.192	
Nov 2005		0.204			0.417			3.395			2.166	
Dec 2005		0.256			0.487			3.462			2.217	

Mon Year	A	D R L(TL)	A - B	A	G T	A / B	A	M H H W	A - B	A	M L L W	A - B
	METER	METER	RATIO	METER	METER	RATIO	METER	METER	METER	METER	METER	METER
Jan 2005	4.579	2.809	1.770	1.921	1.842	1.043	5.539	3.730	1.809	3.618	1.888	1.730
Feb 2005	4.567	2.800	1.767	1.872	1.797	1.042	5.503	3.698	1.805	3.631	1.901	1.730
Mar 2005	4.505	2.728	1.777	1.771	1.683	1.052	5.391	3.569	1.822	3.620	1.886	1.734
Apr 2005	4.387	2.628	1.759	1.820	1.735	1.049	5.297	3.495	1.802	3.477	1.760	1.717
May 2005	4.438	2.680	1.758	1.891	1.815	1.042	5.383	3.588	1.795	3.492	1.773	1.719
Jun 2005	4.439	2.683	1.756	1.959	1.894	1.034	5.418	3.630	1.788	3.459	1.736	1.723
Jul 2005	4.521	2.764	1.757	1.971	1.929	1.022	5.507	3.728	1.779	3.536	1.799	1.737
Aug 2005	4.526	2.776	1.750	1.873	1.839	1.018	5.462	3.695	1.767	3.589	1.856	1.733
Sep 2005	4.498	2.755	1.743	1.739	1.705	1.020	5.368	3.607	1.761	3.629	1.902	1.727
Oct 2005		2.718			1.699			3.567			1.868	
Nov 2005		2.674			1.850			3.599			1.749	
Dec 2005		2.724			1.988			3.718			1.730	

Figure 4.7. Monthly Mean Simultaneous Comparison Example

COMPARISON OF MONTHLY MEANS (Jan 2005 - Dec 2005)
1983-2001 TIDAL EPOCH

Feb 01, 2007

(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY

	M T L A - B METER	M S L A - B METER	H W I A - B HRS	L W I A - B HRS	M N A / B RATIO
TOTAL MONTHS	9.000	9.000	9.000	9.000	9.000
SUMS	15.809	15.904	3.880	5.800	9.494
MEANS	1.757	1.767	0.431	0.644	1.055
ACCEPTED FOR B	2.792	2.773	7.535	0.848	1.248
CORRECTED FOR A	4.549	4.540	7.966	1.492	1.317

	D H Q A / B RATIO	D L Q A / B RATIO	M H W A - B METER	M L W A - B METER
TOTAL MONTHS	9.000	9.000	9.000	9.000
SUMS	9.090	8.893	16.111	15.510
MEANS	1.010	0.988	1.790	1.723
ACCEPTED FOR B	0.186	0.346	3.416	2.168
CORRECTED FOR A	0.188	0.342	5.206	3.891

	D R L(TL) A - B METER	G T A / B RATIO	M H H W A - B METER	M L L W A - B METER
TOTAL MONTHS	9.000	9.000	9.000	9.000
SUMS	15.837	9.322	16.128	15.550
MEANS	1.760	1.036	1.792	1.728
ACCEPTED FOR B	2.712	1.780	3.602	1.822
CORRECTED FOR A	4.472	1.844	5.394	3.550

METHOD	DATUM	VALUE
MODIFIED RANGE RATIO	MHHW =	5.394
MODIFIED RANGE RATIO	MLLW =	3.550
MODIFIED RANGE RATIO	DHQ =	0.187
MODIFIED RANGE RATIO	DLQ =	0.340
STANDARD	MHW =	5.207
STANDARD	MLW =	3.890
STANDARD	MHHW =	5.395
STANDARD	MLLW =	3.548
DIRECT	MN =	1.315
DIRECT	GT =	1.844
DIRECT	DHQ =	0.188
DIRECT	DLQ =	0.342

FINAL/PRELIMINARY DATUMS			
MHHW	---	---	5.395
MHW	-	-	5.207
MTL	-	-	4.549
DTL	-	-	4.472
MSL	-	-	4.540
MLW	-	-	3.890
MLLW	---	---	3.548
ON STAFF OF:			

DHQ	1.88
GT	1.846
MN	1.317
DLQ	0.342

TABULATED _____

VERIFIED _____

Figure 4.7. Monthly Mean Simultaneous Comparison (continued)

COMPARISON OF MONTHLY MEANS (Jan 2005 - Dec 2005)														Feb 01, 2007	
1983-2001 TIDAL EPOCH															
(A) SUBORDINATE STATION 9414863 RICHMOND, CHEVRON OIL PIER	Product										TM (OW)		TIDE TYPE (M)		
(B) STANDARD STATION 9414290 SAN FRANCISCO, SAN FRANCISCO BAY	Product										TM (OW)		TIDE TYPE (M)		
O U T L I E R R E P O R T															
(MEAN DIFFERENCE EXCEEDS 2 STD. DEV. (MAX/MIN))															
Std. Dev.	M T L	M S L	H W I	L W I	M N	D H Q	D L Q	M H W	M L W	D T L	G T	M H H W	M L L W	Std. Dev.	
MAX	0.009	0.007	0.014	0.034	0.007	0.008	0.016	0.013	0.005	0.007	0.008	0.013	0.004	MAX	
MIN	1.774	1.780	0.459	0.712	1.069	1.025	1.021	1.816	1.734	1.774	1.052	1.818	1.736	MIN	
MON YEAR	1.739	1.754	0.404	0.577	1.041	0.995	0.956	1.765	1.713	1.745	1.020	1.766	1.719		
Jan 2005														Jan 2005	
Feb 2005														Feb 2005	
Mar 2005	1.780	1.784						1.820	1.739	1.777	1.052	1.822		Mar 2005	
Apr 2005			0.390				1.021						1.717	Apr 2005	
May 2005													1.719	May 2005	
Jun 2005				0.720										Jun 2005	
Jul 2005			0.460										1.737	Jul 2005	
Aug 2005					1.040						1.018			Aug 2005	
Sep 2005	1.733	1.746			1.039	1.032	0.941	1.756	1.708	1.743		1.761		Sep 2005	
Oct 2005														Oct 2005	
Nov 2005														Nov 2005	
Dec 2005														Dec 2005	

Figure 4.7. Monthly Mean Simultaneous Comparison (concluded)

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service

Page 1 of 8

Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

To reach the tidal bench marks, proceed west along U.S. Highway 101 in the direction of the Golden Gate Bridge, then NW along Crissey Field Avenue (before the bridge) to the Golden Gate National Park (Presidio). The bench marks are located mostly along the coast in the vicinity. The tide gauge is located on the NE side of the National Parks Service wharf.

T I D A L B E N C H M A R K S

PRIMARY BENCH MARK STAMPING: 180 1936
DESIGNATION: 941 4290 TIDAL 180

MONUMENTATION: Tidal Station disk VM#: 967
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0702
SETTING CLASSIFICATION: Concrete sea wall

The primary bench mark is a disk set in the top of a 1 m (3 ft) high concrete seawall in Golden Gate National Park at the Gulf of Farallons National Marine Sanctuary headquarters, 15 m (50 ft) east of the NE corner of the Sanctuaries building, 6.10 m (20.0 ft) south of the south side of the garage building, and 1.07 m (3.5 ft) north of an angle in wall.

BENCH MARK STAMPING: BM 174 1925
DESIGNATION: 941 4290 TIDAL 174
ALIAS: TIDAL 174

MONUMENTATION: Tidal Station disk VM#: 971
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0697
SETTING CLASSIFICATION: Concrete monument

The bench mark is a disk set in a concrete post flush with the ground inside a circle of bricks in the pavement, 38.10 m (125.0 ft) west of the extended west edge of Engineer's Dock where it crosses Marine Drive, at the center of "Y" between Marine Drive and the road leading SE to Fort Winfield Scott, 12.95 m (42.5 ft) SW of the fire hydrant, and 8.69 m (28.5 ft) south of the south edge of an iron manhole cover.

Figure 4.8. Published Bench Mark Sheet

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Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: BM 176 1925
DESIGNATION: 941 4290 TIDAL 176
ALIAS: TIDAL 176

MONUMENTATION: Tidal Station disk VM#: 972
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0705
SETTING CLASSIFICATION: Concrete step

The bench mark is a disk set in the west end of the lowest concrete step at the main entrance to the porch of the building at No. 651 Mason Street, 29.87 m (98.0 ft) SE of the intersection of Crissey Field Avenue and Mason Street, 15.24 m (50.0 ft) south of the centerline of Mason Street, and 0.21 m (0.7 ft) above sidewalk.

BENCH MARK STAMPING: 181 1945
DESIGNATION: 941 4290 TIDAL 181
ALIAS: TIDAL 181

MONUMENTATION: Tidal Station disk VM#: 973
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0701
SETTING CLASSIFICATION: Sea wall

The bench mark is a disk set in NW corner of a sea wall at the Golden Gate National Park at the Gulf of Farallons National Marine Sanctuary headquarters, 62 m (204 ft) west of the inshore end of the pier, 45.87 m (150.5 ft) NW of a flag pole, 21.64 m (71.0 ft) NE of the north corner of Building S.F. 19.4 (paint shop and storage building), and 1.22 m (4.0 ft) above ground.

Figure 4.8 Published Bench Mark Sheet (continued)

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Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: NO 2 1948
DESIGNATION: CLARK RM 2
ALIAS: 941 4290 TIDAL 183

MONUMENTATION: Triangulation Station disk VM#: 975
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0700
SETTING CLASSIFICATION: Sea wall

The bench mark is a disk set flush in the top of a sea wall west of the public fishing pier, 11.43 m (37.5 ft) west of the west edge of the pier, 8.08 m (26.5 ft) NE of the NE corner of corrugated iron building No. 985, and about 0.91 m (3.0 ft) above ground.

BENCH MARK STAMPING: CLARK 1948
DESIGNATION: CLARK
ALIAS: 941 4290 TIDAL 185

MONUMENTATION: Triangulation Station disk VM#: 976
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0698
SETTING CLASSIFICATION: Concrete sea wall

The bench mark is a disk set in the top of a concrete sea wall west of the public fishing pier, about 549 m (1800 ft) NW of the Gulf of Farallons National Marine Sanctuary headquarters in Golden Gate National Park, 24.23 m (79.5 ft) west of the west edge of the pier, 6.86 m (22.5 ft) NE of the NW corner of corrugated iron building No. 985, 3.05 m (10.0 ft) west of the NW corner of a stucco paint locker building, and 1.07 m (3.5 ft) above ground.

Figure 4.8: Published Bench Mark Sheet (continued)

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Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: 4290 K 1976
DESIGNATION: 941 4290 K TIDAL

MONUMENTATION: Tidal Station disk VM#: 978
AGENCY: National Ocean Service (NOS) PID: HT2255
SETTING CLASSIFICATION: Bedrock

The bench mark is a disk set vertically in bedrock on the south side of Marine Drive, 24 m (79 ft) SSW of the SE corner of the National Park Service building # T989, 14.69 m (48.2 ft) NW of bench mark BM 174 1925, and 2.44 m (8.0 ft) south of the road curb.

BENCH MARK STAMPING: 4290 L 1976
DESIGNATION: 941 4290 L TIDAL

MONUMENTATION: Tidal Station disk VM#: 979
AGENCY: National Ocean Survey (NOS) PID: HT2253
SETTING CLASSIFICATION: Bedrock

The bench mark is a disk set in bedrock on the south side of Marine Drive, 114 m (375 ft) west of the National Park Service building # T989, 15.70 m (51.5 ft) SE of the eastern-most concrete and steel safety chain stanchion on the seawall, 7.77 m (25.5 ft) from the centerline of Marine Drive, and 1.22 m (4 ft) above street level.

Figure 4.8: Published Bench Mark Sheet (continued)

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Station ID: 9414290 PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO
CALIFORNIA
NOAA Chart: 18649 Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH Longitude: 122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: 4290 M 1982
DESIGNATION: 941 4290 M TIDAL

MONUMENTATION: Tidal Station disk VM#: 980
AGENCY: National Ocean Survey (NOS) PID: HT3538
SETTING CLASSIFICATION: Concrete foundation

The bench mark is a disk set flush in concrete foundation in front of Stilwell Hall (building # 650) on Mason Street, 27.34 m (89.7 ft) south of the centerline of Mason street, 10.30 m (33.8 ft) east of the NE corner of the west wing of the Stilwell Hall, 6.07 m (19.9 ft) west of the west edge of the sidewalk leading to the entrance of Stilwell Hall, 0.30 m (1.0 ft) SE of the NW corner of the foundation, and 0.12 m (0.4 ft) above ground level.

BENCH MARK STAMPING: BM 175 1925
DESIGNATION: 941 4290 TIDAL 175
ALIAS: TIDAL 175

MONUMENTATION: Tidal Station disk VM#: 1829
AGENCY: US Coast and Geodetic Survey (USC&GS) PID: HT0696
SETTING CLASSIFICATION: Sea wall

The bench mark is a disk set in top surface of the sea wall, near the National Park Service building at the intersection of the pavement and the seawall, 65.23 m (214.0 ft) NE of bench mark 4290 L 1976, 58.67 m (192.5 ft) west from the NW corner of the National Park Service building, 28.90 m (94.8 ft) WNW of the northern-most post of pedestrian gate, 6.86 m (22.5 ft) north of the centerline of Marine Drive, and 0.73 m (2.4 ft) south from the north edge of the sea wall.

Figure 4.8: Published Bench Mark Sheet (continued)

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Station ID:	9414290	PUBLICATION DATE:	04/21/2003
Name:	SAN FRANCISCO		
	CALIFORNIA		
NOAA Chart:	18649	Latitude:	37° 48.4' N
USGS Quad:	SAN FRANCISCO NORTH	Longitude:	122° 27.9' W

T I D A L B E N C H M A R K S

BENCH MARK STAMPING: 4290 N 1995
DESIGNATION: 941 4290 N

MONUMENTATION:	Tidal Station disk	VM#:	15436
AGENCY:	National Ocean Service (NOS)	PID:	AE5209
SETTING CLASSIFICATION:	Concrete sea wall		

The bench mark is a disk set in a concrete seawall in Golden Gate National Park at the Gulf of Farallons National Marine Sanctuary headquarters, near an inshore end of a walkway leading to a pier, 13.70 m (44.9 ft) north of bottom of stairs leading to the Sanctuary building, 3.96 m (13.0 ft) east of a step in seawall, and 3.20 m (10.5 ft) west of the center of the walkway.

Figure 4.8: Published Bench Mark Sheet (continued)

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Station ID: 9414290	PUBLICATION DATE: 04/21/2003
Name: SAN FRANCISCO	
CALIFORNIA	
NOAA Chart: 18649	Latitude: 37° 48.4' N
USGS Quad: SAN FRANCISCO NORTH	Longitude: 122° 27.9' W

T I D A L D A T U M S

Tidal datums at SAN FRANCISCO based on:

LENGTH OF SERIES:	19 Years
TIME PERIOD:	January 1983 - December 2001
TIDAL EPOCH:	1983-2001
CONTROL TIDE STATION:	

Elevations of tidal datums referred to Mean Lower Low Water (MLLW), in METERS:

HIGHEST OBSERVED WATER LEVEL (01/27/1983)	=	2.640
MEAN HIGHER HIGH WATER (MHHW)	=	1.780
MEAN HIGH WATER (MHW)	=	1.595
MEAN TIDE LEVEL (MTL)	=	0.970
MEAN SEA LEVEL (MSL)	=	0.951
MEAN LOW WATER (MLW)	=	0.346
MEAN LOWER LOW WATER (MLLW)	=	0.000
NORTH AMERICAN VERTICAL DATUM-1988 (NAVD)	=	-0.018
LOWEST OBSERVED WATER LEVEL (12/17/1933)	=	-0.877

Bench Mark Elevation Information In METERS above:

Stamping or Designation	MLLW	MHW
180 1936	3.972	2.378
BM 174 1925	5.013	3.418
BM 176 1925	4.814	3.219
181 1945	3.987	2.392
NO 2 1948	4.221	2.626
CLARK 1948	4.233	2.639
4290 K 1976	5.828	4.234
4290 L 1976	6.620	5.025
4290 M 1982	3.705	2.111
BM 175 1925	4.160	2.566
4290 N 1995	3.646	2.051

Figure 4.8: Published Bench Mark Sheet (continued)

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Station ID:	9414290	PUBLICATION DATE:	04/21/2003
Name:	SAN FRANCISCO		
	CALIFORNIA		
NOAA Chart:	18649	Latitude:	37° 48.4' N
USGS Quad:	SAN FRANCISCO NORTH	Longitude:	122° 27.9' W

D E F I N I T I O N S

Mean Sea Level (MSL) is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD 88).

NGVD 29 is a fixed datum adopted as a national standard geodetic reference for heights but is now considered superseded. NGVD 29 is sometimes referred to as Sea Level Datum of 1929 or as Mean Sea Level on some early issues of Geological Survey Topographic Quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after holding mean sea level observed at 26 long term tide stations as fixed. Numerous local and wide-spread adjustments have been made since establishment in 1929. Bench mark elevations relative to NGVD 29 are available from the National Geodetic Survey (NGS) data base via the World Wide Web at http://www.ngs.noaa.gov/cgi-bin/ngs_opsd.prl?PID=HT0702&EPOCH=1983-2001.

NAVD 88 is a fixed datum derived from a simultaneous, least squares, minimum constraint adjustment of Canadian/Mexican/United States leveling observations. Local mean sea level observed at Father Point/Rimouski, Canada was held fixed as the single initial constraint. NAVD 88 replaces NGVD 29 as the national standard geodetic reference for heights. Bench mark elevations relative to NAVD 88 are available from NGS through the World Wide Web at http://www.ngs.noaa.gov/cgi-bin/ngs_opsd.prl?PID=HT0702&EPOCH=1983-2001.

NGVD 29 and NAVD 88 are fixed geodetic datums whose elevation relationships to local MSL and other tidal datums may not be consistent from one location to another.

The Vertical Mark Number (VM#) and PID# shown on the bench mark sheet are unique identifiers for bench marks in the tidal and geodetic databases, respectively. Each bench mark in either database has a single, unique VM# and/or PID# assigned. Where both VM# and PID# are indicated, both tidal and geodetic elevations are available for the bench mark listed.

The NAVD 88 elevation is shown on the Elevations of Tidal Datums Table Referred to MLLW only when two or more of the bench marks listed have NAVD 88 elevations. The NAVD 88 elevation relationship shown in the table is derived from an average of several bench mark elevations relative to tide station datum. As a result of this averaging, NAVD 88 bench mark elevations computed indirectly from the tidal datums elevation table may differ slightly from NAVD 88 elevations listed for each bench mark in the NGS database.

Figure 4.8: Published Bench Mark Sheet (concluded)

4.4.4. Quality Control

It is essential for tidal datum quality control to have data processing and leveling procedures carried out to the fullest extent. Caution must also be used in computing tidal datums in riverine systems or in regions of unknown tidal regimes. Tide-by-tide comparisons between subordinate and control station data will often detect anomalous differences which should be investigated for possible gauge malfunction or sensor movement. Datums shall be established from more than one bench mark. Differences in elevations between bench marks based on new leveling must agree with previously established differences from the published bench mark sheets. Any changes in the elevation differences must be reconciled before using in any datum recovery procedure. Datum accuracy at a subordinate station depends on various factors, but availability and choice of an adequate control station of similar tidal characteristics, similar daily mean sea level and seasonal mean sea level variations, and similar sea level trends are the most important. The length of series will also determine accuracy. The longer the series, the more accurate the datum and the greater quality control and confidence gained from analyzing numerous monthly mean differences between the subordinate and control station. At reoccupied historical stations for which datum recoveries are made, updated datums shall be computed from the new time series and compared with the historical datums as the survey progresses.

4.5. Final Zoning and Tide Reducers

Data relative to MLLW from subordinate stations or from NWLON stations, as appropriate, shall be applied to reduce sounding data to chart datum, either directly or indirectly through a correction technique referred to as tidal zoning. Whether corrected or direct, time series data relative to MLLW or other applicable LWD applied to reference hydrographic soundings to chart datum are referred to as “tide reducers” or “water level reducers”.

4.5.1. Water Level Station Summaries

Data are reduced to mean values and subsequently adjusted to National Tidal Datum Epoch (NTDE) values for tidal datums and characteristic tidal attributes as prescribed in Section 4.4. and 4.5. “Summary files” shall be created for each subordinate tide station occupied for the survey. These summary data facilitate the development of corange and cophase lines and final zoning schemes. They also provide input into the NOS tidal datum bench mark publication process which supports navigation, boundary and shoreline determination, coastal engineering and management. NTDE values for Greenwich high and low water intervals, mean and diurnal ranges and high and low water inequalities shall be tabulated in these summary files which also contain the datums, the time and length of the series and NOS control station which was used to compute 19-year equivalent NTDE values. NTDE datums shall be tabulated in the summary file relative to a documented consistent station datum such as tide staff zero or arbitrary station datum. The elevation of the primary bench mark shall be provided in this summary relative to the same zero or station datum. Latitude and longitude positions shall also be provided. An example of a summary file is provided in Figure 4.9.

Summary file data from new station occupations and NOS provided summaries from historical occupation and control stations within the survey area shall be used as input data to the tidal zoning process.

4.5.2. Construction of Final Tidal Zoning Schemes

As tidal characteristics vary spatially, data from deployed water level gauges may not be representative of water levels across a survey area. Tidal zoning shall be implemented to facilitate the provision of time series water level data relative to chart datum for any point within the survey area such that prescribed accuracy requirements are maintained for the water level measurement component of the hydrographic survey. NOS currently utilizes the “discrete tidal zoning” method for operations, where survey areas are broken up into a scheme of zones bounding areas of common tidal characteristics. The minimum requirement is for a new zone for every 0.06 m change in mean range of tide and every 0.3 hour progression in time of tide (Greenwich high and low water intervals). Phase and amplitude corrections for appropriate tide station data shall be assigned to each zone.

As part of the process, tidal characteristics shall be accessed using geographic spatial placement of summary data in a commercial GIS compatible format to assess spatial variations in tidal characteristics. Corange and cophase maps shall be generated to provide the base for development of zoning schemes. Preliminary zoning, which is based on available historical tide station data and estuarine and global tide models, is referenced to an applicable predictions reference station for utilization during field work. For final processing, preliminary zoning shall be superseded by “final zoning” which is a refinement based on new data collected at subordinate stations during the survey. With the final zoning scheme, correctors for each zone shall be derived from a subordinate station specifically installed for the survey rather than the reference station used with preliminary zoning. For contract surveys, the contractor shall develop and utilize a zoning scheme to the specifications mentioned above such that water level reducers are within required accuracy across the entire survey area. Zoning errors shall be minimized such that when combined with errors from actual water level measurement at the gauge and errors in reduction to chart datum, the total error of the tide reducers is within specified tolerances. The final zoning scheme and all data utilized in its development shall be documented and submitted. Examples of zoning files and graphics are provided in Figures 4.10, 4.11, 4.12, 4.13 and 4.15.

4.5.3. Tide Reducer Files and Final Tide Note

Verified time series data collected at appropriate subordinate stations are referenced to the NTDE Mean Lower Low Water (Chart Datum) through datum computation procedures outlined in Section 4.4. Time series data collected in six-minute intervals and reduced to chart datum as specified, both from subordinate gauges operated by the contractor and from NWLON stations where appropriate, shall be used either directly or corrected through use of a zoning scheme as determined appropriate by the contractor such that tide reducers are within specified tolerances. A Final Tide Note shall be submitted for each hydrographic sheet with information as to what final tidal zoning should be applied to which stations to obtain the final tide reducers. An example Final Tide Note and final tidal zoning graphic is found in Figure 4.15.

Anchorage, AK (9455920)						
ACCEPTED DATUMS		Station ID - 9455920				
EPOCH: 1983-2001						
HWL	12.454					
MHHW	10.800	DHQ	0.222			
MHW	10.578					
MTL	6.587			GT	8.889	
DTL	6.356			MN	7.982	
NAVD88						
MSL	6.931					
MLW	2.596	DLQ	0.685			
MLLW	1.911					
LWL	-0.038					
Meters						
		HWI	3.65			
		LWI	10.41			
Balance?						
DHQ	DLQ	MN	GT	MTL	DTL	
YES	YES	YES	YES	YES	YES	
Stage		Date		ID		
Complete:		12-4-02		233		
Verified:		12-4-02		102		
Accepted:		4-17-03		888		
Source		Control Station				
MANUAL		N/A				
Staff		PBM				
5-1-1964		NO 15 RESET 1966				
Segments						
Begin		I		End		
01/01/97 00:00		I		12/31/01 00:00		
		I				
		I				
		I				
		I				
		I				
Extreme		Date		Time		
HWL		10-24-1980		18:18		
LWL		12-25-1999		12:42		

Figure 4.9. Tide Station Summary

STATION	NAME	ST	HWM	LWI	TOHHM	TCLLWI	MN	CHQ	DLQ	QT	EPOCH	SERIES	HA_SERIES	COMP_STAT	COMMENTS	LATITUDE	LONGITUDE
9455176	BURNIT ISLAND, JURNALAN ARM	AK	3.67	10.25	N/A	N/A	28.0	0.8	2.4	31.2		4-HL, 1918	N/A	Fire Island		80.95000000	-149.83333333
9455182	CARRI POINT, KNIK HARBOR	AK	3.69	10.35	N/A	N/A	26.97	0.76	2.38	30.11		22-HL, 1918	N/A	Anchorage staff		81.23333333	-149.81666667
9455187	SISTERS ROCK, COOK INLET	AK	0.31	6.85	N/A	N/A	18.31	0.85	2.02	19.18	41-59	34-HZL, Jul-Aug79	N/A	Seldovia		-151.45500000	-151.45500000
9455111	CAPE KASLOF, COOK INLET	AK	0.43	6.80	N/A	N/A	17.66	0.80	2.08	20.34	41-59	60-HL, Jun-Aug74	N/A	Seldovia		80.33999999	-151.39000000
9455115	KASLOF, KASLOF RIVER	AK			N/A	N/A						36H, Jul80	N/A		High waters only	80.35833333	-151.27666667
9455172	KALGIN ISLAND (WEST)	AK	0.38	6.71	N/A	N/A	15.83	0.71	1.90	18.24	41-59	123-HZL, Jun-Aug74	N/A	Seldovia	mean of 2 series	80.45333333	-151.95666667
9455178	LIGHT POINT, KALGIN ISLAND	AK	0.70	7.13	N/A	N/A	15.95	0.70	2.00	18.65		58-HL, Jul-Aug75	N/A	Nikiski		80.48999999	-151.83500000
9455195	CHINULNA POINT, COOK INLET	AK	0.68	7.22	N/A	N/A	17.89	0.74	2.02	20.65	60-78	1Mo, Jun65	N/A	Seldovia	3 series	80.50333333	-151.26333333
9455197	KENAI RIVER	AK	0.80		N/A	N/A		0.87		41-59		240y, Jul-Aug74	N/A	Nikiski	High waters only	80.52719999	-151.20666667
9455141	DRIFT RIVER	AK	0.69	7.04	N/A	N/A	15.58	0.68	1.93	18.19		64-HL, Jul-Aug74	N/A	Seldovia	superseded	80.55500000	-152.13333333
9455142	KENAI	AK	0.78	7.75	N/A	N/A	14.49	0.73	1.94	19.86	41-59	2Mo, Jun-Jul78	N/A	Seldovia		80.54500000	-151.21833333
9455160	WEST FORELAND	AK	1.22	7.80	N/A	N/A	17.68	0.70	2.08	20.47	60-78	5Y1, 1972-75377	N/A	Seldovia		80.68333333	-151.39666667
9455168	NIKISHKA, 1ST EAST FURCUNA	AK	1.53	7.58	N/A	N/A	13.30	0.88	2.25	18.21	60-78	1Mo, Jul76	N/A	Seldovia		80.71333333	-151.71000000
9455171	PLATFORM DILLON, T-39 COOK INLET	AK	1.43	8.03	N/A	N/A	18.05	0.49	2.11	20.65		9-HL, 1909	N/A	Seldovia		80.73333333	-151.33333333
9455172	NIKISHKA #2, COOK INLET	AK	1.46	7.70	N/A	N/A	17.28					4Mo, Jul-Oct71	N/A	Seldovia	CHART 16860	80.73999999	-151.51333333
9455178	SHELL PLATFORM, GIDOLE GROUND	AK	1.59	8.22	N/A	N/A	17.33	0.85	2.21	20.19	41-59	1Mo, 1988	N/A	Seldovia	Chart 16860	80.74333333	-151.30833333
9455179	JUMBO ROCK, BOULDER POINT	AK	1.83	8.48	N/A	N/A	18.02	0.88	2.08	20.76	41-59	15-HL, Sep76	N/A	Nikiski		80.78700000	-151.17000000
9455192	DOLLY YARDEN PLATFORM, COOK INLET	AK	1.68	8.14	N/A	N/A	16.22	0.88	2.11	19.01		1Mo, Dec71	N/A	Anchorage		80.80833333	-151.63666667
9455193	TRADING BAY, COOK INLET	AK	1.47	7.88	N/A	N/A	18.5	0.8	2.20	19.50		22-HL, 1910	N/A	Seldovia/1st Red, Anchorage		80.80716667	-151.77666667
9455187	GRAY CLIFFE	AK	1.95	8.58	N/A	N/A	19.47	0.79	2.06	22.32	41-59	2Mo, Jul-Aug77	N/A	Anchorage		80.83333333	-150.87166667
9455189	MIDDLE RIVER, COOK INLET	AK			N/A	N/A						24-HL, Jul75	N/A	Nikiski		80.87166667	-151.81666667
9455190	T-37 PLATFORM (OPR 489)	AK	2.73	9.23	N/A	N/A	16.82	0.63	2.15	19.80	60-78	4-HL, 1910	N/A	Nikiski		80.92833333	-151.53000000
9455194	MOOSE POINT	AK			N/A	N/A	20.6	0.8	2.3	23.7			N/A	Chinulna Pt		80.95300000	-150.73166667
9455198	MOOSE POINT T3 (OPR 489)	AK			N/A	N/A							N/A			80.97500000	-150.80666667
9455208	T-28 CHICALON BAY, TURNAGAN ARM	AK	2.25	8.88	N/A	N/A	16.73	0.85	2.08	19.48		62-HL, Jul-Aug1975	N/A	Nikiski		81.00000000	-149.85000000
9455145	T-39 PLATFORM, OFF GRANITE POINT	AK	3.59	11.28	N/A	N/A	27.51	0.59	1.96	29.66		20-HL, Jul1975	N/A	Anchorage		81.02000000	-149.64000000
9455146	T-29 RAINBOW (OPR 489)	AK	2.32	8.77	N/A	N/A	17.5	0.8	2.3	20.6		4-HL, 1910	N/A	Chinulna Pt		81.02000000	-151.31666667
9455168	TYONEK, COOK INLET	AK	3.00	9.85	N/A	N/A	23.19	0.86	2.30	28.05	41-59	1Mo, Jul1975	N/A	Anchorage		81.03999999	-150.41300000
9455168	T-39 POINT POSSESSION (OPR 489)	AK	2.71	9.03	N/A	N/A	17.88	0.81	2.08	20.57	41-59	107-HL, Jun-Aug1975	N/A	Anchorage		81.04830000	-151.15830000
9455168	NORTH FORELAND	AK	2.79	9.21	N/A	N/A	19.20	0.84	2.19	13.04	60-78	1Mo, Jul1975	N/A	Nikiski	GP changed 5/5/98 not verified	81.07570000	-150.95166667
9455168	PHILLIPS PLATFORM	AK	2.68	9.18	N/A	N/A	19.2	0.8	2.3	22.3		7-HL, 1919	N/A	Anchorage		81.14333333	-151.07500000
9455111	THREE MILE CREEK, COOK INLET	AK			N/A	N/A	24.6	0.7	2.2	27.5		22-HZL, May1941	N/A	Chinulna Pt		81.15666667	-150.24000000
9455111	FRE ISLAND (WEST SIDE)	AK			N/A	N/A							N/A			81.17333333	-150.21333333
9455112	FRE ISLAND	AK	3.27	10.00	N/A	N/A	24.01	0.85	2.08	28.74	60-78	108-HZL, May-Jun1982	N/A	Anchorage		81.19666667	-150.03000000
9455115	PT. WORONZOF	AK	3.41	10.15	N/A	N/A	24.43	0.88	2.12	27.23	60-78	2Mo, Jul-Aug1971	N/A	Anchorage		81.23833333	-149.88633333
9455120	ANCHORAGE, KNIK ARM, COOK INLET	AK	3.72	10.42	N/A	N/A	28.25	0.71	2.28	29.24	60-78	5Y1, 1984-81	N/A	Seldovia		80.40333333	-152.25500000
9455121	ANCHORAGE (ADR)	AK			N/A	N/A							N/A			80.40333333	-152.39500000
9455143	HARBOR POINT	AK	0.50	6.72	N/A	N/A	14.19	0.70	1.95	18.84	41-59	100-HZL, Jun-Jul1974	N/A	Seldovia		80.30716667	-151.95666667
9455184	REDoubt Pt	AK	0.33	6.50	N/A	N/A	14.01	0.44	1.95	18.40	41-59	1Mo, Jul75	N/A	Nikiski			

Figure 4.10. GIS Summary Data File

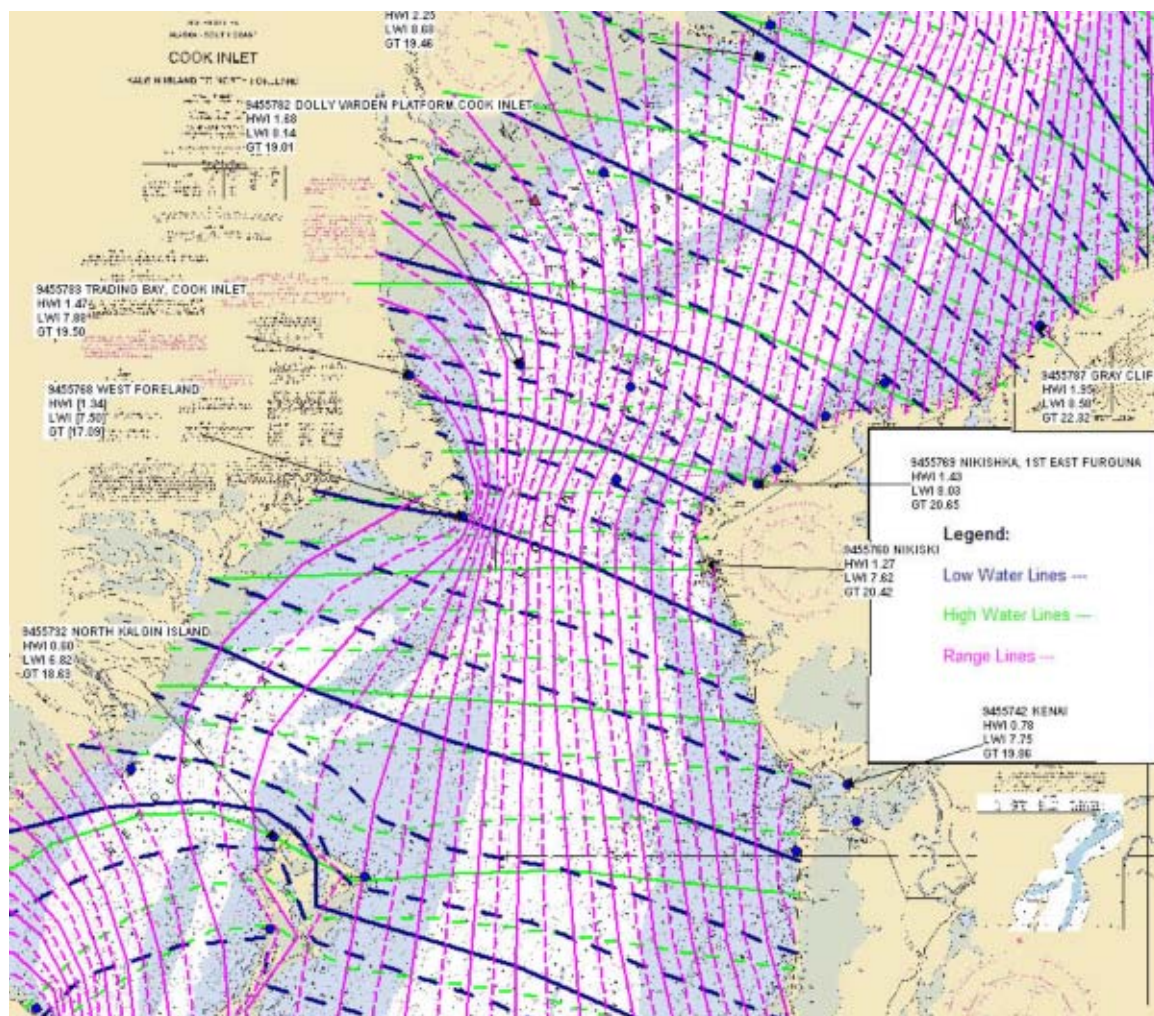


Figure 4.11. Corange Line of Greenwich, High and Low Water Intervals (In Hours)



		WL VALUE	WL	quality control			
STATION DATE/TIME		on MLLW	SIGMA	inferred	flat	flags: rofc	temp
	utc	meters	meters				
9414290	10/1/98 0:00	1.373	0.042	0	0	0	0
9414290	10/1/98 0:06	1.390	0.043	0	0	0	0
9414290	10/1/98 0:12	1.403	0.036	0	0	0	0
9414290	10/1/98 0:18	1.424	0.039	0	0	0	0
9414290	10/1/98 0:24	1.426	0.033	0	0	0	0
9414290	10/1/98 0:30	1.436	0.034	0	0	0	0
9414290	10/1/98 0:36	1.458	0.032	0	0	0	0
9414290	10/1/98 0:42	1.489	0.035	0	0	0	0
9414290	10/1/98 0:48	1.507	0.032	0	0	0	0
9414290	10/1/98 0:54	1.520	0.038	0	0	0	0
9414290	10/1/98 1:00	1.533	0.042	0	0	0	0
9414290	10/1/98 1:06	1.537	0.029	0	0	0	0
9414290	10/1/98 1:12	1.541	0.033	0	0	0	0
9414290	10/1/98 1:18	1.548	0.032	0	0	0	0
9414290	10/1/98 1:24	1.572	0.033	0	0	0	0
9414290	10/1/98 1:30	1.596	0.037	0	0	0	0
9414290	10/1/98 1:36	1.609	0.039	0	0	0	0
9414290	10/1/98 1:42	1.624	0.036	0	0	0	0
9414290	10/1/98 1:48	1.639	0.040	0	0	0	0
9414290	10/1/98 1:54	1.638	0.036	0	0	0	0
9414290	10/1/98 2:00	1.649	0.032	0	0	0	0
9414290	10/1/98 2:06	1.658	0.036	0	0	0	0
9414290	10/1/98 2:12	1.659	0.033	0	0	0	0
9414290	10/1/98 2:18	1.660	0.041	0	0	0	0
9414290	10/1/98 2:24	1.671	0.029	0	0	0	0
9414290	10/1/98 2:30	1.669	0.039	0	0	0	0
.	.	.	.				
.	.	.	.				
.	.	.	.				
.	.	.	.				
9414290	11/30/98 23:00	0.350	0.120	0	0	0	0
9414290	11/30/98 23:06	0.342	0.124	0	0	0	0
9414290	11/30/98 23:12	0.343	0.090	0	0	0	0
9414290	11/30/98 23:18	0.359	0.106	0	0	0	0
9414290	11/30/98 23:24	0.389	0.079	0	0	0	0
9414290	11/30/98 23:30	0.412	0.087	0	0	0	0
9414290	11/30/98 23:36	0.446	0.128	0	0	0	0
9414290	11/30/98 23:42	0.459	0.102	0	0	0	0
9414290	11/30/98 23:48	0.399	0.089	0	0	0	0
9414290	11/30/98 23:54	0.463	0.136	0	0	0	0

Figure 4.13. Example Tide Reducer File from NOAA Acoustic System

4.6. Data Submission Requirements

Data submission requirements for water level measurement stations are comprised of both supporting documents for the installation, maintenance, and removal of stations, and the formatted digital water level data collected by the water level measurement system required for NOS quality control and ingestion into the NOS data base management system. In addition, documentation for processing and tabulation of the data, tidal datum computation, and final tidal zoning are required.

Data submission requirements for GPS project consists of project reports, station (bench mark) description or recovery notes, observation log sheets, station visibility diagrams, photographs or rubbings of station marks, raw GPS data, Rinex GPS data, and other info as pertinent.

4.6.1. Station Documentation

The documentation package shall be forwarded to CO-OPS within 15 business days of: a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, or d) removal of the station. Refer to Section 4.2.6 for general documentation requirements and Figure 4.14, Water Level Station Documentation Checkoff List. The station documentation generally includes, but is not limited to the following:

- (a) Field Tide Note
- (b) Calibration test documentation from an independent source other than the manufacturer for each sensor used to collect water level or ancillary data.
- (c) NGWLMS Site Report (see Next Generation Water level Measurement System Site Design, Preparation, and Installation Manual), and/or Tide Station Report (NOAA Form 77-12), or Great Lakes Water Level Station Report (NOAA Form 77-75) or equivalent. Contractor created Site Reports are acceptable as long as the reports provide same required information.
- (d) New or updated Nautical chart section or U.S. Geological Survey quadrangle map indicating the exact location of the station, with chart number or map name and scale shown.
- (e) Large-scale sketch of the station site and digital GIS compatible file provided on electronic formats currently used such as CD-ROM or DVD-ROM showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (derived from handheld GPS) of the gauge and all bench marks.
- (f) New or updated description of how to reach the station from a major geographical landmark.
- (g) Photographs of station components and bench marks. Digital photographs are preferred. As a minimum, photographs shall show a view of the water level measurement system as installed, including sensors and DCP; a front view of the staff (if any); multiple views of the surroundings and other views necessary to document the location; and photographs of each bench mark, including a location view and a close-up showing the bench mark stamping. All photographs shall be annotated and referenced with the station name, number, location, and date of the photograph.

- (h) Description/Recovery Notes of Bench Marks (see User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).
- (i) Level records and level abstract, including level equipment information.
- (j) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor "zero" is referenced to the bench marks.

4.6.2. GPS Project Documentation

The following information in addition to the results obtained from OPUS shall be submitted to CO-OPS at the end of the project (see the time frames for submission of GPS data later in Section 4.6.6) so that proper information can be forwarded to NGS for blue-booking purposes.

This documentation is important because most of the information is used to submit the GPS data to NGS. In addition to the log, data must comply with the "Data Submission to NGS Section" of NGS-58 and the "Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base" to become part of the NSRS.

GPS data collected by contractors or NOAA Ships for hydrographic survey support, or special projects shall be processed by the parties, and final data product - Receiver Independent Exchange Format (RINEX) data and appropriate forms - shall be submitted to CO-OPS which will be forwarded to NGS, as per the contracts, project instructions, Statement of Work, or as appropriate.

GPS forms in PDF format can be found at the following NGS Federal Base Network web site:
<http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm>

Refer to Figure 4.16 through 4.22 for GPS projects submission checklist and sample package contents.

- (A) Project report (Refer to Figure 4.16):
One project report per GPS project is required.
- (B) Station (bench mark) description or recovery notes (Refer to Figure 4.17)
One per bench mark, for which GPS observations are submitted, is required.
- (C) Observation log sheets (Refer to Figure 4.18 and 4.19)
One per each GPS observation session is required.
- (D) Station/bench mark visibility diagrams (Refer to Figure 4.20)
One per each bench mark, for which GPS observations are submitted, is required.
- (E) Photographs or rubbings of station (bench) marks (Refer to Figure 4.22 and 4.21)
One per each bench mark, for which GPS observations are submitted, is required.
- (F) Raw GPS data
- (G) Rinex GPS data
- (H) OPUS results

I. For Each Water Level Station:**PROJECT DOCUMENTATION AND DATA CHECKOFF LIST**

Project Number: _____ Locality: _____

Station Number: _____ Station Name: _____

A. Field Tide Note

- _____ 1. Verify latitude and longitude with handheld GPS.
- _____ 2. Verify dates.

B. Site Report (required for both installation and removal)

- _____ 1. All applicable information complete, especially serial numbers of DCP/sensors and dates of installation/removal of DCP/sensors and levels
- _____ 2. Verify latitude and longitude (ensure that this is the same as on the field tide note).
- _____ 3. Denote latitude and longitude as NAD 83. Also note if position was derived from handheld GPS.

C. Chart Section

- _____ 1. Ensure that station location is clearly depicted with circle and station number.
- _____ 2. Note chart number, edition, date and scale.

D. Bench Mark/Station Location Sketch

- _____ 1. Gauge/staff and bench marks shown.
- _____ 2. Title block provided (NOAA Form 76-199).
- _____ 3. North arrow depicted.
- _____ 4. Include hard copy sketch and GIS digital format on electronic formats currently used such as CD-ROM or DVD-ROM.

E. Photographs

- _____ 1. Digital photographs of gauge, staff and surrounding area.

F. Bench Mark Descriptions/Recovery Notes

- _____ 1. Stampings for new and recovered marks verified.
- _____ 2. Descriptions for new marks provided in NOS format (MS Word).
- _____ 3. Recovery notes provided for all historical marks.

G. Levels

- _____ 1. Ensure all information written in ink.
- _____ 2. Cover information complete; station name, number, instrument and rod type, serial numbers, date, personnel.
- _____ 3. Note types of levels; installation, bracketing and closing.
- _____ 4. Staff information complete (if applicable).
- _____ 5. Collimation check shown.
- _____ 6. Note that bench mark descriptions are submitted on separate sheets.
- _____ 7. Headers on all applicable pages complete.

H. Datum Offset Computation Worksheet

- _____ 1. Submit for stations using Vitel or Sutron 8200 DCP with Aquatrak sensor.

I. Data Submitted on electronic formats currently in use such as CD-ROM or DVD

- _____ 1. Label CD-ROM or DVD with contractor name and list of files on each.
- _____ 2. Data files should be named in the following format: xxxxxxx1.dat, where xxxxxxx = seven digit station number and 1 is the DCP designation. For multiple files from the same station, change the extension, i.e., xxxxxxx1.da1, da2, etc.
- _____ 3. Check the begin and end dates submitted with dates of hydrographic operations.
- _____ 4. Check data continuity

II. For the Project:**A. Files**

- _____ 1. GIS files for final zoning
- _____ 2. Final Tide Reducer Files for each H-Sheet

B. Final Tide Notes

- _____ 1. Final Tide Note for each H-Sheet

C. Transmittal Letter

- _____ 1. Transmittal letter attached with current contractor address, phone number and email.

D. All Documentation Enclosed in Tide Level Envelope (NOAA Form 75-29A)

- _____ 1. Leave "sheets" box blank, complete other information in title boxes.
- _____ 2. Verified complete by contractor and Include date.

Figure 4.14. Project Documentation and Data Checkoff List

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: December 22, 1999

HYDROGRAPHIC BRANCH: Pacific

HYDROGRAPHIC PROJECT: OPR-342-RA-99

HYDROGRAPHIC SHEET: H-10910

LOCALITY: 6 NM Northwest of Cape Kasilof, AK

TIME PERIOD: July 22 - August 20, 1999

TIDE STATION USED: 945-5711 Cape Kasilof, AK

Lat. 60° 20.2'N Lon. 151° 22.8'W

PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters

HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 5.850 meters

REMARKS: RECOMMENDED ZONING

Use zone(s) identified as: CK394, CK395, CK399, CK400, CK401, CK407, CK408, CK409, CK434, CK435, CK441, CK442, CK443, CK467, CK468, CK469, CK470, CK477, CK480, CK481, CK482, CK483, CK493 & CK494.

Refer to attachments for zoning information.

Note 1: Provided time series data are tabulated in metric units (Meters), relative to MLLW and on Greenwich Mean Time.

Note 2: Nikiski, AK served as datum control for subordinate tide stations and for tidal zoning in this hydrographic survey. Accepted datums for this station have been updated recently and have changed significantly from previous values.

The current National Tidal Datum Epoch (NTDE) used to compute tidal datums at tide stations is the 1960-78 NTDE. Traditionally, NTDEs have been adjusted when significant changes in mean sea level (MSL) trends were found through analyses amongst the National Water Level Observation Network (NWLON) stations. Epochs are updated to ensure that tidal datums are the most accurate and practical for navigation, surveying and engineering applications and reflect the existing local sea level conditions. For instance, analyses of sea level trends show that a new NTDE is necessary and efforts are underway to update the 1960-1978 NTDE to a more recent 19-year time period.

Note: This example of Field Tide Note and Final Tidal Zoning Chart was written in December 1999, at that time NTDE was 1960-1978, now the new NTDE is 1983-2001.

Figure 4.15. Final Tide Note and Final Tidal Zoning Chart

However, analyses also show that there are several geographic areas whose sea level trends are strongly anomalous from the average trends found across the NWLON and thus, must be treated differently. One of these areas is in Cook Inlet, Alaska. Nikiski has shown a significant relative sea level change due to continued vertical land movement after the 1964 earthquake. NOS has adopted a procedure for computing accepted tidal datums for this anomalous region by using an MSL value calculated from the last several years of data rather than the 19-year NTDE. The accepted range of tide is still based on the 19-year NTDE and, when applied to the updated MSL, will result in updated values for Mean High Water (MHW) and Mean Lower Low Water (MLLW) derived through standard datum calculation procedures. For Nikiski, the MSL value was computed from the period of 1994-1998. This resulted in a lowering of the MLLW datums relative to land by approximately 1.0 ft at Nikiski compared to the previous MLLW elevations used in surveys prior to January 1, 1998. Subordinate tide stations in the area used for hydrographic surveys and controlled by Nikiski will be affected similarly. Accepted datums have been computed and may be accessed on the Internet through the URL specification <http://www.tidesandcurrents.noaa.gov>.

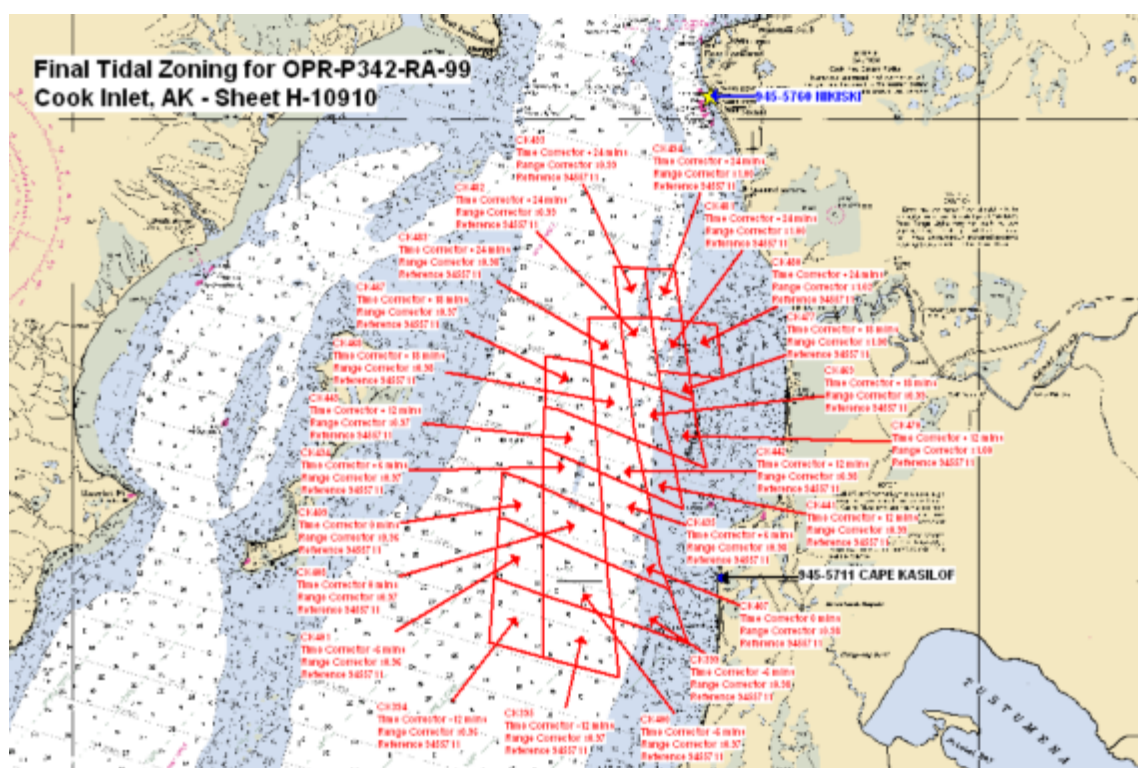


Figure 4.15. Final Tide Note and Final Tidal Zoning Chart (continued)

PROJECT SUBMISSION CHECKLIST**GPS PROJECTS**

Project Title: _____

Submitting Agency: _____

Observing Agency: _____

Receiver Type: _____

Antenna Type: _____

PACKAGE CONTENTS

- () Project Report
- () Station Description or Recovery notes
- () Observations Logs Sheets
Data which must be filled out: Station Designation, Date (UTC), General Location, Day of Year, Project Name, Session ID, Observation Session Times, Agency Full Name, Operator Full Name, Phone Number, GPS Receiver, GPS Antenna, Antenna Height, Data File Name
- () Station Visibility Diagrams
- () Photographs or Rubbings of Station Marks
- () Raw GPS data
- () Rinex GPS Data - See below
- () OPUS results
- () Other

DATA REFORMATTING

Convert the raw GPS data to RINEX2 format with your manufacturer's software. The software should require you to enter the raw data filename, the output filenames, your name, the observer's name and agency, and the antenna type used.

The NGS-standard data filenames are as follows:

Raw GPS input files: aaaaddds.xxx

Where: aaaa = alphanumeric 4-character station identifier, ddd = day of year, s = session, yy = year of observations, and xxx is the receiver-dependent file extension (e.g., .DAT, .EPH, .ION, .MES, etc.)

RINEX2 Navigation File: aaaaddds.yyn

RINEX2 Observation File: aaaaddds.yyo

For example, RINEX2 filenames from station BALD 2 on session A of 12/31/98 are ALD365A.98o and BALD365A.98n

Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch electronic formats currently in use such as a CD ROM.

Figure 4.16. Project Submission Checklist

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY STATION DESCRIPTION / RECOVERY FORM

PID: QE2736 Designation & Alias: BALD 2 RESET
 Country: USA / USA State: OR County: LINCOLN
 Latitude: N 44 49 49.17802 " Longitude: W 124 08 56.23447 " Elevation: 17.0 (meter / ft)

Original Description (check one):		Recovery Description (check one):	
<input type="checkbox"/> P	Preliminary (mark has not been set yet)	<input type="checkbox"/> F	Full description of a station <u>not</u> in the database
<input type="checkbox"/> D	A newly set mark	<input checked="" type="checkbox"/> T	Full description of a station <u>in</u> the database
<input checked="" type="checkbox"/> R	A recovered mark	<input type="checkbox"/> M	<u>Partial</u> description of a station in the database
Established by: (NGS / CGS / Other:) <u>Oregon DOT</u>		Recovered by: (NGS / Other:) <u>Oregon DOT</u>	
Date: _____ Chief of Party (initials): <u>???</u>		Date: _____ Chief of Party (initials): <u>CFS</u>	

Monument Stability (check one):		Recovery Condition (check one):	
<input checked="" type="checkbox"/> A	Of the most reliable nature; expected to hold well	<input checked="" type="checkbox"/> G	Recovered in good condition
<input type="checkbox"/> B	Will probably hold position and elevation well	<input type="checkbox"/> N	Not recovered or not found
<input type="checkbox"/> C	May hold well, but subject to ground movement	<input type="checkbox"/> P	Poor, disturbed, or mutilated
<input type="checkbox"/> D	Of questionable or unknown reliability	<input type="checkbox"/> X	Surface mark known destroyed

Setting Information:		Stamping:	
Marker Type: (Rod / Disk / Other)		<u>BALD 2 1991</u>	
Setting Type: (Bedrock / Concrete / Other)		Agency Inscription: (NGS / CGS / Other:) <u>Oregon DOT</u>	
<input checked="" type="checkbox"/> / N / ? Monument contains magnetic material?		Rod Depth: _____ (meter/ft), Sleeve Depth: _____ (meter/ft)	
		Monument is: (flush / projecting / recessed) _____ (cm/inch)	

Special Type (check all applicable):		Transportation (check one):	
<input type="checkbox"/> F	Fault monitoring site	<input checked="" type="checkbox"/> C	Car
<input type="checkbox"/> T	Tidal Station	<input type="checkbox"/> P	Light truck (pickup, carry-all, etc.)
<input checked="" type="checkbox"/> --	Control Station: (FBN / CBN / Bench mark)	<input type="checkbox"/> X	Four-Wheel Drive Vehicle
<input type="checkbox"/> --	Airport Control Station: (PACS / SACS)	<input type="checkbox"/> __	Other (SnowCat, Plane, Boat, describe)
<input checked="" type="checkbox"/> / N	Mark is suitable for GPS use?	<input checked="" type="checkbox"/> / N	Pack Time (hike) to mark? (hh:mm): <u>00:03</u>

See Back of Form to add Text Description

Figure 4.17. Station Description/Recovery Form

General Station Location: The station is located in about 10 km south from Lincoln Bay, 13 km north from Depoe Bay, and at the US101 Boiler Bay wayside rest area.

(Describe general location; include airline distances to three towns or mapped features.)

Ownership: The station is on the property of Oregon State Department of Parks and Recreation.

(name, address, phone of landowner)

To Reach Narrative: To reach the station from the intersection of US routes 5 and 101 in Depoe Bay, go north on US 101 for 1 km to the south entrance of the Boiler Bay wayside. Bear left on entrance road for 0.4 km to the parking area on the left. Pack northwest inside fence for about 90 meters to end of fence and the station on the right.

(Leg-by-leg distances and directions from major road intersection to mark)

Monument Description and Measurements: The station is set into drill hole in bedrock, 7.6 m south from the north fence corner, 8.8 m east from the west fence corner, and 3.6 m southeast from the northwest end of the outcrop.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

NOTE: - Include a pencil rubbing, sketch, or photographs of mark.

Described by: John Q. Surveyor Phone: (301)713-3194 e-mail: jqs@ordot.gov

--> Click here to clear the sample data <--


 GPS STATION OBSERVATION LOG (01-Nov-2000)	Station Designation: (check applicable: FBN / <input checked="" type="checkbox"/> CBN / PAC / SAC / <input checked="" type="checkbox"/> NM) BALD 2 RESET		Station PID, if any: QE2736		Date (UTC): 31-Dec-98	
	General Location: Boiler Bay Wayside		Airport ID, if any: ---		Station 4-Character ID: BALD	
Project Name: Sample GPS, 1998		Project Number: GPS- 1234		Station Serial # (SSN):		Session ID (A,B,C etc): A
NAD83 Latitude 44 49 49.17802		NAD83 Longitude 124 03 56.23447		NAD83 Ellipsoidal Height -6.44 meters		Agency Full Name: Oregon DOT
Observation Session Times (UTC): Sched. Start 12:00 Stop 17:30		Epoch Interval = 15 Seconds		NAVD88 Orthometric Ht. 17.0 meters		
Actual Start 11:55 Stop 17:32		Elevation Mask = 10 Degrees		GEOID99 Geoid Height -23.52 meters		Operator Full Name: John Q. Surveyor
GPS Receiver: Manufacturer & Model: Leica SR530 P/N: p/n 667122 S/N: s/n 0030354 Firmware Version: Version 3.0 <input checked="" type="checkbox"/> CamCorder Battery, <input type="checkbox"/> 12V DC, <input type="checkbox"/> 110V AC, <input type="checkbox"/> Other		GPS Antenna: Manufacturer & Model: Trimble Choke Ring P/N: p/n 29659-00 S/N: s/n 02200-63591 Cable Length, meters: 30 meters Vehicle is Parked 25 meters N (direction) from antenna.		Antenna plumb before session? <input checked="" type="checkbox"/> (Y/N) Circle Antenna plumb after session? <input checked="" type="checkbox"/> (Y/N) Yes or No Antenna oriented to true North? <input checked="" type="checkbox"/> (Y/N) -If no, explain Weather observed at antenna ht? <input checked="" type="checkbox"/> (Y/N) Antenna ground plane used? <input checked="" type="checkbox"/> (Y/N)		Antenna radome used? (Y/N) <input checked="" type="checkbox"/> If yes, describe. Eccentric occupation (>0.5 mm)? (Y/N) <input checked="" type="checkbox"/> Use Any obstructions above 10'? (Y/N) <input checked="" type="checkbox"/> Vis. form Radio interference source nearby (Y/N) <input checked="" type="checkbox"/>
Tripod or Ant. Mount: Check one: <input checked="" type="checkbox"/> Fixed-Height Tripod, <input type="checkbox"/> Slip-Leg Tripod, <input type="checkbox"/> Fixed Mount Manufacturer & Model: SECO P/N: none. S/N: 97-G Last Calibration date: 1998-11-01		** ANTENNA HEIGHT ** (see back of form for measurement illustration)		Before Session Begins: measure and record both Meters AND Feet After Session Ends: measure and record both Meters AND Feet		
Tribrach: Check one: <input checked="" type="checkbox"/> None, <input type="checkbox"/> Wild GDF 22, <input type="checkbox"/> Topcon, <input type="checkbox"/> Other (describe) Last Calibration date:		A = Datum point to Top of Tripod (Tripod Height) B = Additional offset to ARP if any (Tribrach/Spacer) H = Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)		2.000 -0.003 2.000 -0.003		
Barometer: Manufacturer & Model: pretel altiplus A2 P/N: none. S/N: J.Q.S. Last Calibration or check Date: 11-Sep-01		Weather DATA Time (UTC) Dry-Bulb Temp Fahrenheit Celsius WetBulb Temp Fahrenheit Celsius Rel. % Humidity Altn. Pressure inches Hg. millibar Weather Codes *		Before 12:00 74.0 68.0 74 29.4 00000		
Psychrometer: Manufacturer & Model: Psychrodyne S/N: J.Q.S.		Middle 14:45 77.0 72.5 81 29.6 00001		After 17:30 82.5 78.0 82 29.7 00102		
		Average of Readings		Calculate * See back of form for codes		
Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc: 1. Winds, calm at start, gradually increased to 20 knots by end of session. 2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment. 3. Center pole of tripod projected 3 mm into dimple of disk. Antenna height was therefore 2 m - 3 mm = 1.997 m Note: Entries are Required in all Unshaded areas.						
Data File Name(s): BALD365A.dat (Standard NGS Format = aaaaaddss.xxx) where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension				Updated Station Description: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier Visibility Obstruction Form: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier Photographs of Station: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier Pencil Rubbing of Mark: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier		
				LOG CHECKED BY: JGE		

Figure 4.18. GPS Station Observation Log

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length (**A**) and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) (**B**)

$$\text{Antenna Height} = H = A + B$$

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #	Notch #	Notch #	Average
Before, cm	223.40	223.30	223.30	
Before, inch	87.95	87.94	87.93	
After, cm	223.40	223.40	223.30	
After, inch	87.97	87.96	87.95	
Note: cm = inch x (2.54)		Overall average, cm		

$$S = \text{_____ cm}$$

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements

$$R = \text{19.05 cm}$$

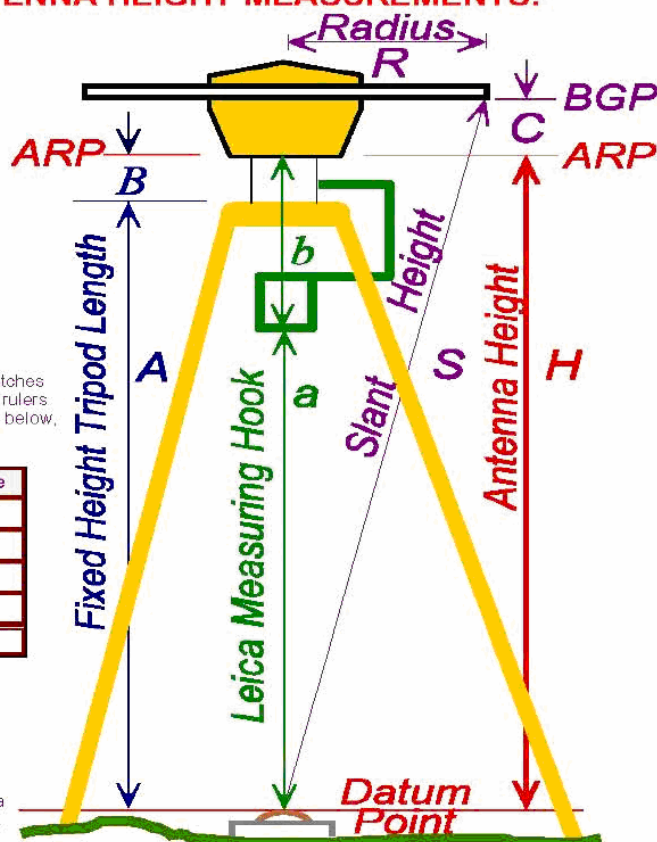
$$C = \text{3.50 cm}$$

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$\text{Antenna Height} = H = ((\sqrt{S^2 - R^2}) - C)$$

$$\text{Antenna Height} = H = a + b$$



III. Instructions for using the Leica Brand Measuring Hook:

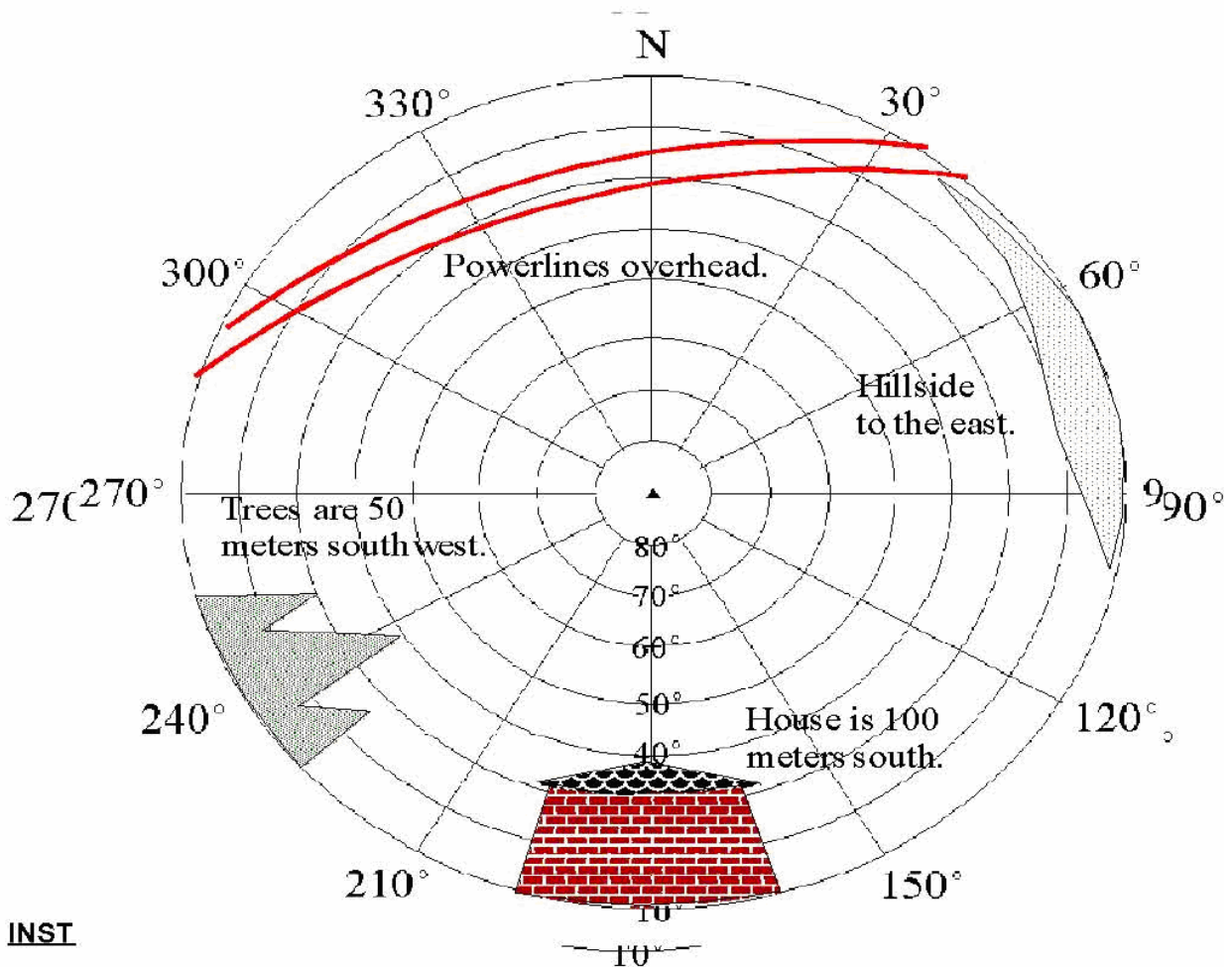
Follow the Leica operating instructions, being sure to reduce the height to the Antenna Reference Point (ARP), NOT the L1 Phase Center.

Table of Weather Codes -- for entry into Weather Data Table on front of form:					
CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80° F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80° F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over 15mph (24km/h)
Examples: Code 00000 = 0 - No problems, 0 - good visibility, 0 - normal temperature, 0 - clear sky, 0 - calm wind Code 12121 = 1 - Problems, 2 - poor visibility, 1 - hot temperature, 2 - overcast, 1 - moderate wind					

Figure 4.19. GPS Antenna Height Measurements

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY VISIBILITY OBSTRUCTION DIAGRAM



INST

Identify obstructions by azimuth (magnetic) and elevation angle (above horizon) as seen from station mark. Indicate distance and direction to nearby structures and reflective surfaces (potential multipath sources).

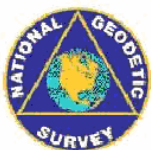
Designation: BALD 2 RESET PID: QE2736

Location: Boiler Bay Wayside County: LINCOLN

Reconnaissance By: John Q. Surveyor Height above mark: 2 Meters

Agency/Company: Oregon DOT Phone: ((301)) 713-3194 Date: 1998-12-31

Figure 4.20. Visibility Obstruction Diagram



Station Pencil Rubbing Form

--> Click here to clear the sample data <--

Location / Airport Name and ID _____		Boiler Bay Wayside	Project _____	Sample GPS, 1998
Station Designation _____		BALD 2 RESET	PID _____	QE2736 Date 1998-12-31
Circle all applicable: PACS SACS <input checked="" type="checkbox"/> FEN <input checked="" type="checkbox"/> OTHER _____		Observer & Organization _____ John Q. Surveyor, ORDOT		
Station Pencil Rubbing				
<p><u>Instructions:</u> Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.</p>				
Remarks: This disk is reset into the same drill hole as the original station BALD 1962.		Monument Type _____ Brass Disk Inscribed Agency _____ Oregon DOT Stamping _____ BALD 2 1991		

Figure 4.21. Station Pencil Rubbing Form



Figure 4.22. Digital Photo of Stamping of Bench Mark

4.6.3. Water Level Data

The final observed water level measurements shall be reported as heights in meters to three decimal places (i.e. 0.001 m). All heights shall be referenced to station datum and shall be referenced to UTC. The final tide reducer time series data shall be referenced to MLLW and shall be referenced to UTC. The contractor shall provide, within 15 business days of the removal of stations/gauges, to CO-OPS with the water level data in the format specified below from all water level gauges installed.

The original raw water level data and also the correctors used to convert the data to chart datum shall be retained until notified in writing or at least two years after the survey is completed. All algorithms and conversions used to provide correctors shall be fully supported by the calibrations, maintenance documentation, leveling records, and sound engineering/oceanographic practices. Sensors for measurements used to convert data (e.g. pressure to heights) shall be calibrated and maintained for the entire water level collection period.

All digital water level and ancillary data shall be transmitted to CO-OPS in a format dependent on the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo binary format (see NGWLMS GOES Message Formatting, Libraro, 1/2003). These satellite messages are then decoded by NOS DMS upon receipt from NESDIS before further processing

and review by CORMS can be completed. If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to NOS, as shown in the format below, in a digital format, on CD-ROM, or by email as an ASCII data attachment. It may be prudent to submit data at more frequent intervals under specific circumstances. Data download files shall be named in the following format: xxxxxxxy.DAZ, where xxxxxxx is the seven digit station number, y is the DCP number (usually 1), and DAZ is the extension (where Z = 1,2,3...if more than one file is from the same station and DCP). This is the format needed when the data is loaded into DMS. Also each water level data file (XXX.BWL or XXX.ACO) shall have only 3 months of data. If the water level station was operational for more than three months, please submit multiple xxxxxxxy.DAZ files, each file with only three months of data.

The 6-minute interval data (acoustic sensor and pressure sensor examples follow) shall have the following format for CO-OPS database to accept.

Acoustic Sensor Data (XXX.ACO format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
 Column 8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
 Column 9-19 Date (MMM DD YYYY format, e.g. JAN 01 1998)
 Column 20-20 Blank
 Column 21-22 Hours in 24 hour format (i.e. 01, 01, ..., 23)
 Column 23-23 : (colon)
 Column 24-25 Minutes (00,06,12,etc..
 Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
 Column 33-38 Sigma (standard deviation in millimeters in integer format)
 Column 39-44 Outlier (integer format)
 Column 45-50 Temperature 1 (tenth of degrees C in integer format)
 Column 51-56 Temperature 2 (tenth of degrees C in integer format)
 Column 57-58 Sensor type (A1 for acoustic type)
 Column 59-60 blank
 Column 61-61 Data Source (S for Satellite, D for CD-ROM or DVD-ROM)

Sample data:

```
85169901AUG 17 1993 05:00 1138 23 0 308 297A1 D
85169901AUG 17 1993 05:06 1126 26 0 308 298A1 D
85169901AUG 17 1993 05:12 1107 26 1 309 298A1 D
```

Pressure Sensor or Generic Data (XXX.BWL format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
 Column 8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
 Column 9-19 Date (MMM DD YYYY format, e.g. JAN 01 1998)
 Column 20-20 Blank
 Column 21-22 Hours in 24 hour format (i.e. 01, 01, ..., 23)
 Column 23-23 : (colon)
 Column 24-25 Minutes (00-59)
 Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
 Column 33-38 Sigma (standard deviation in millimeters in integer format)
 Column 39-44 Outlier (integer format)
 Column 45-50 DCP temperature (tenth of degrees C in integer format)
 Column 51-52 Sensor type (Z1 for generic or pressure)
 Column 53-53 blank
 Column 54-54 Data Source (S for Satellite, D for CD-ROM or DVD-ROM)

Sample data:

```
85169901AUG 17 1993 05:00 1138 23 0 308Z1 D
85169901AUG 17 1993 05:06 1126 26 0 308Z1 D
85169901AUG 17 1993 05:12 1107 26 1 309Z1 D
```

Note: pressure data must be accompanied by documented staff observations as listed in Section 4.2.2. and 4.2.4, if applicable.

4.6.4. Tabulations and Tidal Datums

For contract surveys, the contract hydrographer shall provide digital and hard copies of tabulations of staff/gauge differences, hourly heights, high and low waters, monthly means, and water level datums for the entire time series of observations from each water level station. Along with the final contractor computed tidal datums, the contractor shall provide copies of the tide-by-tide and/or monthly mean simultaneous comparison sheets from which the final tidal datums were determined. Audit trails of data edits and gap-filling shall be summarized and provided also. The contractor shall provide, within 15 business days of the removal of stations/gauges, to CO-OPS with the hourly height, high/low data, monthly mean data, and station datum data, in the format specified below for all the water level gauges installed.

The digital tabulation files for hourly heights, high and low waters, monthly means, and station datum shall have the following formats:

Hourly Height data Format:

```
Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 Blank
Column 9-16 Date (YYYYMMDD format, e.g. 20070120)
Column 17-17 Blank
Column 18-19 Hours (2 digits 00-23, use leading zeros)
Column 20-20 : (colon)
Column 21-22 Minutes (2 digits 00-59, use leading zeros)
Column 23-23 Blank
Column 24-30 Water level value in meters (F7.3 format, e.g. 123.456)
```

Sample data:

```
9414290 20040101 00:00 123.456
```

High/Low Data Format:

```
Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 Blank
Column 9-16 Date (YYYYMMDD format, e.g. 20070120)
Column 17-17 Blank
Column 18-19 Hours (2 digits 00-23, use leading zeros)
Column 20-20 : (colon)
Column 21-22 Minutes (2 digits 00-59, use leading zeros)
```

Column 23-23 Blank
Column 24-30 Water level value in meters (F7.3 format, e.g. 123.456)
Column 31-31 Blank
Column 32-33 Water level high/low type (H, L, HH, or LL)

Sample data:

9414290 20040101 00:00 123.456 HH

Definition of Acronym:

H: Higher low water level value
L: Lower high water level value
HH: Higher high water level value
LL: Lower low water level value

Monthly Mean Data Format:

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 Blank
Column 9- 12 Year (YYYY format, e.g. 2007)
Column 13- 13 Blank
Column 14- 15 Month (in 2 digits 01-12, use leading zeros)
Column 16- 16 Blank
Column 17- 23 MHHW in meters (F7.3 format, e.g. 123.456)
Column 24- 24 Blank
Column 25- 31 MHW in meters (F7.3 format, e.g. 123.456)
Column 32- 32 Blank
Column 33- 39 DTL in meters (F7.3 format, e.g. 123.456)
Column 40- 40 Blank
Column 41- 47 MTL in meters (F7.3 format, e.g. 123.456)
Column 48- 48 Blank
Column 49- 55 MSL in meters (F7.3 format, e.g. 123.456)
Column 56- 56 Blank
Column 57- 63 MLW in meters (F7.3 format, e.g. 123.456)
Column 64- 64 Blank
Column 65- 71 MLLW in meters (F7.3 format, e.g. 123.456)
Column 72- 72 Blank
Column 73- 79 GT in meters (F7.3 format, e.g. 123.456)
Column 80- 80 Blank
Column 81- 87 MN in meters (F7.3 format, e.g. 123.456)
Column 88- 88 Blank
Column 89- 95 DHQ in meters (F7.3 format, e.g. 123.456)
Column 96- 96 Blank
Column 97-103 DLQ in meters (F7.3 format, e.g. 123.456)
Column 104-104 Blank
Column 105-111 Maximum Water Level in meters (F7.3 format, e.g. 123.456)
Column 112-112 Blank
Column 113-120 Maximum Water Level Date (in YYYYMMDD format, last occurrence)
Column 121-121 Blank
Column 122-123 Maximum Water Level Hour (2 digits 00-23, use leading zeros)
Column 124-124 : (colon)
Column 125-126 Maximum Water Level Minute (2 digits 00-59, use leading zeros)
Column 127-127 Blank

Column 128-128 Maximum Water Level occurrences (1 digit)
 Column 129-129 Blank
 Column 130-136 Minimum Water Level in meters (F7.3 format, e.g. 123.456)
 Column 137-137 Blank
 Column 138-145 Minimum Water Level Date (in YYYYMMDD format, last occurrence)
 Column 146-146 Blank
 Column 147-148 Minimum Water Level Hour (2 digits 00-23, use leading zeros)
 Column 149-149 : (colon)
 Column 150-151 Minimum Water Level Minute (2 digits 00-59, use leading zeros)
 Column 152-152 Blank
 Column 153-153 Minimum Water Level occurrences (1 digit)

Sample data:

Example (with column ruler):

0	0	0	0	0	0	0	0	0
1	2	3	4	5	6	7	8	
1234567890123456789012345678901234567890123456789012345678901234567890								
9414290	2004 01	123.456	123.456	123.456	123.456	123.456	123.456	123.456
0	1	1	1	1	1	1	1	
9	0	1	2	3	4	5		
1234567890123456789012345678901234567890123456789012345678901234567890								
123.456	123.456	123.456	123.456	20040101	00:00	1	123.456	20040101 00:00 1

Definition of Acronym:

MHHW	Mean Higher High Water
MHW	Mean High Water
DTL	Diurnal Tide Level
MTL	Mean Tide Level
MSL	Mean Sea Level
MLW	Mean Lower Water
MLLW	Mean Lower Low Water
GT	Great Diurnal Tide Range
MN	Mean Range of Tide
DHQ	Diurnal High Water Inequality
DLQ	Diurnal Low Water Inequality
MAX_WL	Maximum Water Level during the Month measurement period
MAX_DATE	Date of Maximum Water Level
MAX_HOUR	Hour of Maximum Water Level
MAX_MIN	Minute of Maximum Water Level
MAX_OCCUR	Number of occurrences during the month the Water Level meets the MAX_WL
MIN_WL	Minimum Water Level during the Month measurement period
MIN_DATE	Date of Minimum Water Level
MIN_HOUR	Hour of Minimum Water Level
MIN_MIN	Minute of Minimum Water Level
MIN_OCCUR	Number of occurrences during the month the Water Level meets the MIN_WL

Station Datum Data Format:

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
 Column 8- 16 Blank

Column 17- 23 MHHW in meters (F7.3 format, e.g. 123.456)
 Column 24- 24 Blank
 Column 25- 31 MHW in meters (F7.3 format, e.g. 123.456)
 Column 32- 32 Blank
 Column 33- 39 DTL in meters (F7.3 format, e.g. 123.456)
 Column 40- 40 Blank
 Column 41- 47 MTL in meters (F7.3 format, e.g. 123.456)
 Column 48- 48 Blank
 Column 49- 55 MSL in meters (F7.3 format, e.g. 123.456)
 Column 56- 56 Blank
 Column 57- 63 MLW in meters (F7.3 format, e.g. 123.456)
 Column 64- 64 Blank
 Column 65- 71 MLLW in meters (F7.3 format, e.g. 123.456)
 Column 72- 72 Blank
 Column 73- 79 GT in meters (F7.3 format, e.g. 123.456)
 Column 80- 80 Blank
 Column 81- 87 MN in meters (F7.3 format, e.g. 123.456)
 Column 88- 88 Blank
 Column 89- 95 DHQ in meters (F7.3 format, e.g. 123.456)
 Column 96- 96 Blank
 Column 97-103 DLQ in meters (F7.3 format, e.g. 123.456)
 Column 104-104 Blank
 Column 105-111 Maximum Water Level in meters (F7.3 format, e.g. 123.456)
 Column 112-112 Blank
 Column 113-120 Maximum Water Level Date (in YYYYMMDD format, last occurrence)
 Column 121-121 Blank
 Column 122-123 Maximum Water Level Hour (2 digits 00-23, use leading zeros)
 Column 124-124 : (colon)
 Column 125-126 Maximum Water Level Minute (2 digits 00-59, use leading zeros)
 Column 127-127 Blank
 Column 128-128 Maximum Water Level occurrences (1 digit)
 Column 129-129 Blank
 Column 130-136 Minimum Water Level in meters (F7.3 format, e.g. 123.456)
 Column 137-137 Blank
 Column 138-145 Minimum Water Level Date (in YYYYMMDD format, last occurrence)
 Column 146-146 Blank
 Column 147-148 Minimum Water Level Hour (2 digits 00-23, use leading zeros)
 Column 149-149 : (colon)
 Column 150-151 Minimum Water Level Minute (2 digits 00-59, use leading zeros)
 Column 152-152 Blank
 Column 153-153 Minimum Water Level occurrences (1 digit)

Sample data:

Example (with column ruler):

0	0	0	0	0	0	0	0
1	2	3	4	5	6	7	8
12345678901234567890123456789012345678901234567890123456789012345678901234567890							
9414290	123.456	123.456	123.456	123.456	123.456	123.456	123.456
0	1	1	1	1	1	1	1
9	0	1	2	3	4	5	
12345678901234567890123456789012345678901234567890123456789012345678901234567890							
123.456	123.456	123.456	123.456	20040101	00:00	1	123.456
				20040101	00:00	1	

Definition of Acronyms for Station Datum data are same as that for the Monthly Mean data.

4.6.5. Tide Reducers and Final Zoning and Final Tide Note

The final zoning scheme shall be fully supported by documentation of data and methodology which comprised the final zoning model. The contractor must provide, within 15 business days of removal of stations/gauges, to CO-OPS with his/her final tidal zoning scheme digitally in the MAPINFO or ARCVIEW compatible format. Final tidal zoning scheme in AUTOCAD format is not acceptable.

Final tide reducers shall be submitted in the specified format.

All documentation listed below shall be forwarded to CO-OPS:

- (a) Contractor created summary files.
- (b) Documentation of NOS summary files utilized for final zoning
- (c) GIS compatible zoning development steps including geographical presentation of summary data and cophase/corange maps
- (d) GIS compatible digital final zoning files
- (e) Final tide reducer data files
- (f) Final Tide Note

The final zoning scheme shall be fully supported by documentation of data and methodology which derived the final zoning model.

4.6.6. Submission and Deliverables – Documents and Time lines

The check list in Figure 4.14 shall be used to check and verify the documentation that is required for submission. All documentation, water level data, processed data including hourly height, high/low data, monthly means data, and station datums data, GPS forms and data including OPUS results, zoning and other reports as required, shall be forwarded within 15 business days of the removal of the stations/gauges.

All data and documentation submitted to CO-OPS shall be retained by the contractor for a period of not less than three years or as stipulated in the contract, whichever is longer.

Standard station documentation package includes the following:

- (1) Transmittal letter
- (2) Site Report or tide station report
- (3) Chartlet
- (4) Sensor test worksheet
- (5) Sensor elevation drawing
- (6) Water level transfer form (Great Lakes stations only)
- (7) Barometer Installation Worksheet (Great Lakes stations only)
- (8) Bench mark sketch
- (9) Bench mark descriptions and "Station To Reach" statement
- (10) Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format
- (11) Levels (raw) (electronic files) and field notes of precise leveling
- (12) Abstract of precise leveling
- (13) GPS observations, and visibility diagrams, as applicable

- (14) Staff to gauge observations, if applicable
- (15) Calibration records for sensors, if applicable
- (16) Calibration certificates for Invar leveling rods, if applicable
- (17) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
- (18) Other information as appropriate, or as specified in the contract
- (19) Water level data, all tabulated data, such as hourly heights, high and low, monthly means, and station datums in the specified format.

Generally, for established water level stations, the bench mark sketch, chartlet, and "To Reach" statement need only be submitted if those items have been revised during the station maintenance.

When using the electronic/barcode system, the data disk and hard copies of the abstract and bench mark description or recovery notes shall be submitted. For optical levels, submit the raw levels and the leveling abstract.

For submission in electronic format, the station documentation shall be organized by various folders under the main station number folder, and then pertinent information shall be placed in the various folders and submitted on a digital media such as DVD/CD-ROM etc.

Here is an example of submission of the electronic folders for San Francisco tide station:

- 9414290 San Francisco
- /Transmittal letter
- /Site Report or tide station report
- /Chartlet
- /Sensor test worksheet
- /Sensor elevation drawing
- /Bench mark sketch
- /Bench mark descriptions and "Station To Reach" statement
- /Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format
- /Levels (raw) (electronic files) and field notes of precise leveling
- /Abstract of precise leveling
- /Staff to gauge observations, if applicable
- /Calibration records for sensors, if applicable
- /Calibration certificates for Invar leveling rods, if applicable
- /Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
- /Other information as appropriate, or as specified in the contract
- /Water level data download

Submit required GPS data and forms on a separate DVD, for example, GPS submission for San Francisco tide station will be as follows:

- 9414290 San Francisco
- /GPS observations, and visibility diagrams, as applicable

Submit one copy of all the documentation, water level data, (except GPS submission) in paper and digital format. Submit two copies in digital format of the required GPS submission (GPS forms and data including OPUS results) on a separate DVD.

Submit the completed station package to:

Chief, Requirements and Development Division
NOAA/NOS/CO-OPS/RDD
SSMC 4, Station # 6531
1305 East-West Highway
Silver Spring, MD 20910-3281
Tel # 301-713- 2897 X 145

4.7. Guidelines and References

References for the water level measurement and leveling requirements issued by the NOS Center of Operational Oceanographic Products and Services (CO-OPS) and the National Geodetic Survey (NGS) are listed below.

Some of these documents are available on CO-OPS web site at <http://www.CO-OPS.nos.noaa.gov>.

1. Next Generation Water Level Measurement System (NGWLMS) Site Design, P reparation, and Installation Manual, NOAA/NOS, January 1991.
2. User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, NOAA/NOS, dated October 1987.
3. User's Guide for Writing Bench Marks Descriptions, NOAA/NOS, Updated January 2003.
4. User's Guide for Electronics Levels, NOAA/NOS, updated January 2003.
5. User's Guide for 8200 Bubbler Gauges, NOAA/NOS, updated February 1998.
6. User's Guide for 8200 Acoustic Gauges, NOAA/NOS, updated August 1998.
7. User's Guide for 8210 Bubbler Gauges, NOAA/NOS, updated February 2001.
8. User's Guide for GPS Observations, NOAA/NOS, updated March 2007.
9. Tidal Datums and Their Applications, Special Publication No. CO-OPS 1, NOAA/NOS, June 2000.
10. Manual of Tide Observations, U.S. Department of Commerce, Publication 30-1, Reprinted 1965.
11. Tidal Datum Planes, U.S. Department of Commerce, Special Publication No.135, Marmer 1951.
12. Tide and Current Glossary, U.S. Department of Commerce, NOAA, NOS, October 1989.
13. Standing Project Instructions: Great Lakes Water Levels, June 1978.
14. NOAA Technical Report NOS 64 "Variability of Tidal Datums and Accuracy in Determining Datums from Short Series of Observations", Swanson, 1974.

15. Data Quality Assurance Guidelines for Marine Environmental Programs, Robert J. Farland, Office of Ocean Engineering, NOAA, March, 1980.
16. System Development Plan, CORMS: Continuous Operational Real-Time Monitoring System, NOAA Technical Report NOS OES 014, U.S. Department of Commerce, NOAA, NOS February, 1997.
17. NGWLMS GOES MESSAGE FORMATTING, Phil Libraro, 1/2003.
18. Computational Techniques for Tidal Datums, NOAA Technical Report NOS CO-OPS 2, U.S. Department of Commerce, NOAA, NOS, DRAFT December 1998.
19. Standards and Specifications for Geodetic Control Networks, Federal Geodetic Control Committee, September 1984.
20. NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3", November 1997.
21. Geodetic Leveling, NOAA Manual NOS NGS 3, U.S. Department of Commerce, NOAA, National Ocean Survey, August, 1981.
22. NOAA Special Publication NOS CO-OPS 1 Tidal Datums and Their Applications, February 2001.
23. "Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005"